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WORM PARASITES OF THE BROWN RAT (MUS NORVEGICUS) IN THE PHILIPPINE ISLANDS, WITH SPECIAL REFERENCE TO THOSE FORMS THAT MAY BE TRANSMITTED TO HUMAN BEINGS

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NINETEEN TEXT FIGURES

INTRODUCTION

The rôle of rats as carriers and reservoirs of bubonic plague and other bacterial as well as spirochætal infections, has long been well recognized. For this reason various antirat measures have been in vogue in different parts of the world, especially in seaports, for the control and prevention of these diseases. The fact, however, that these animals are often infested with certain parasitic worms that are also a menace to human health, is not so well known. For this reason and because of the fact that the helminthic fauna of rats in the Philippine Islands has never been studied to any great extent, it seemed worth while to undertake a systematic examination of these animals in order to determine their parasites and to find if they harbor forms that are transmissible to man.

RATS EXAMINED AND THE INCIDENCE OF INFESTATION

The survey was limited to the brown or Norway rat, *Mus norvegicus* Erxleben, 1777 (= *M. decumanus* Pallas, 1778), since this was the only rat constantly available in large numbers. A total of nine hundred fifty of these rodents were dissected

during the period from May 7, 1930, to January 14, 1931. They were trapped in the different sections of the City of Manila and were among those sent to the Bureau of Science by the Philippine Health Service for routine bubonic-plague inspection. A list of the different parasites encountered and their incidence are given in Table 1. One species of roundworm, *Syphacia obvelata*, is not represented in the table, but it is believed to infest rats in the Philippines in view of its having been reported by Riley (1919) in a child residing in Zamboanga, Mindanao.

With the exception of the flukes, a new species of the cestode genus *Raillietina*, and a new nematode in the genus *Rictularia*, all of which are apparently restricted to the Philippines in their distribution, the different worms collected have been reported from other countries. The following were the most commonly met with in the order they are named: The larval form of *Tænia tæniaformis* (commonly known as *Cysticercus fasciolaris*), *Hepaticola hepatica*, *Raillietina garrisoni* sp. nov., *Strongyloides ratti*, *Hymenolepis diminuta*, *Nippostrongylus muris*, *Trichosomoides crassicauda*, and *Gongylonema neoplasticum*. *Hymenolepis nana* and *Heterakis spumosa*, which are common in rats in many countries, were rarely encountered. *Trichinella spiralis*, the most dangerous worm of rats from the public-health standpoint, was not found at all.

TABLE 1.—*Parasites encountered in nine hundred fifty rats.*

Name of parasites.	Infestation. Per cent.
Trematodes:	
Euparyphium ilocanum	0.5
Euparyphium guerreroi	0.1
Euparyphium murinum sp. nov.	0.1
Cestodes:	
Tænia tæniaformis (larval form)	94.0
Raillietina garrisoni sp. nov.	86.0
Hymenolepis diminuta	64.0
Hymenolepis nana	1.7
Nematodes:	
Gongylonema neoplasticum	44.0
Hepaticola hepatica	90.0
Heterakis spumosa	0.4
Nippostrongylus muris	58.0
Protospirura muricola	1.3
Rictularia whartoni sp. nov.	0.4
Strongyloides ratti	74.0
Trichosomoides crassicauda	57.0
Acanthocephala:	
Moniliformis moniliformis	4.2

The incidence of the worms did not seem to depend upon the time of the year but rather, in the case of the flukes, at least, on the environment of their hosts. It was noticed at the termination of the survey that these particular parasites were obtained only from some of the rats that were trapped inside the piers of Manila Bay and in the immediate neighborhood of the landing places of boats along Pasig River. This may be regarded as purely accidental, but it may also mean that either the intermediate hosts of these flukes, which most probably are snails, exist in some of the bodies of water in Manila or the rats that harbored them might have been brought to the city from other localities on board of ships and boats. The matter deserves further inquiry.

DESCRIPTIONS OF PARASITES

The parasites determined represent two phyla in the animal kingdom, namely, the Platyhelminthes, or flatworms, and the Nemathelminthes, or roundworms. The flukes (class Trematoda) and the tapeworms (class Cestoda) are members of the phylum Platyhelminthes, while the so-called true roundworms (class Nematoda) and the proboscis worm (class Acanthocephala) belong to the Nemathelminthes.

Phylum PLATYHELMINTHES Claus, 1885

Class TREMATODA Rudolphi, 1808

Subclass DIGENEA v. Beneden, 1858

Order PROSOSTOMATA Odhner, 1905

Suborder DISTOMATA Zeder, 1800

Superfamily ECHINOSTOMATOIDEA Faust, 1929

Family ECHINOSTOMATIDÆ Looss, 1902

Subfamily ECHINOSTOMATINÆ Looss, 1899

Genus EUPARYPHIUM Dietz, 1909

EUPARYPHIUM ILOCANUM (Garrison, 1908) Tubangui, 1931. fig. 1.

Synonyms: *Fascioletta ilocana* Garrison, 1908; *Echinostoma ilocanum* (Garrison, 1908) Odhner, 1911.

For many years this fluke was regarded as a parasite peculiar to man in the northwestern provinces of Luzon, Philippine Islands. Its occurrence in rats has been only recently demonstrated by the present writer (Tubangui, 1931). In the survey

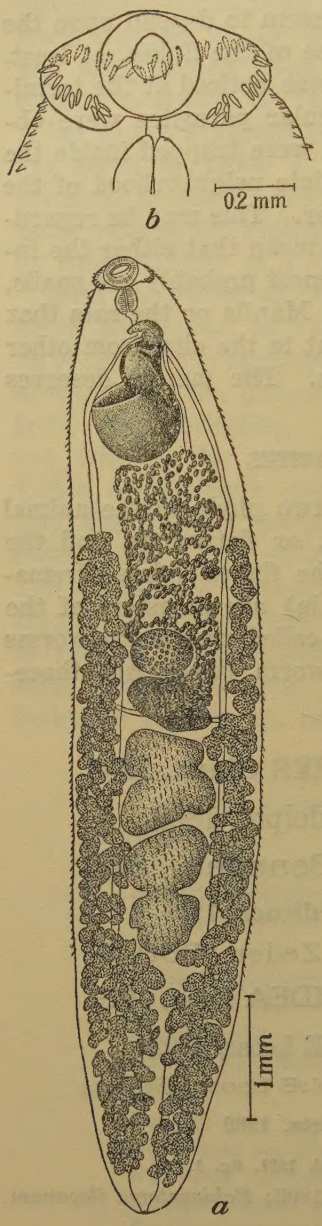

FIG. 1. *Euparyphium ilocanum*. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)

on which this report is based, five or a little more than 0.5 per cent of the nine hundred fifty rats examined were infested with it.

Description.—Body moderately large, elongate, 5.57 to 8.02 millimeters in length by 1.33 to 1.58 millimeters in maximum breadth at or near the equator of body. Lateral sides of body from anterior end to acetabulum rolled ventrally. Cuticle armed with flat scalelike structures distributed ventrally from anterior end to second testis or slightly beyond that level, and dorsally from anterior end to anterior level of acetabulum; scales 13.5 to 24.7 by 13.5 to 18.0 microns in size, those at anterior end being smaller. Suckers close together; oral sucker small, subterminal, 0.19 to 0.24 millimeter in transverse diameter; acetabulum large, cup-shaped, at middle of anterior third of body length, 0.60 to 0.69 by 0.64 to 0.74 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar (fig. 1, *b*) bearing fifty-one spines arranged in two alternating rows; collar 0.38 to 0.46 millimeter in diameter, reniform, its two rounded ventral angles united by a narrow ridge. Collar spines may be grouped as follows: Six ventral corner spines on each side of collar, the smallest of which measures 36.0 by 11.2 microns, the broadest 42.7 by 15.7 microns, and the longest 45.0 by 11.2 microns; fourteen lateral spines on each side, arranged in pairs and eleven dorsal spines; lateral and dorsal spines 31.5 to 45.0 by 11.2 to 13.5 microns in size.

Mouth terminal to subterminal, followed occasionally by prepharynx 0.03 to 0.05 millimeter in length; pharynx 0.19 to 0.20 by 0.15 to 0.17 millimeter in size; œsophagus 0.10 to 0.20 millimeter long, bifurcating immediately in front of genital pore, midway between pharynx and acetabulum or slightly anterior of that level; intestinal cæca reach posteriorly to from 0.24 to 0.43 millimeter from posterior end of body.

Testes tandem, postequatorial, at third fourth of body length, either elongate and each divided into anterior and posterior lobes by transverse constriction or shorter and distinctly 3- to 4-lobed. Cirrus sac large, 0.51 to 0.65 by 0.26 to 0.34 millimeter in size, reaching to but not extending posteriorly beyond equator of acetabulum; incloses prominent seminal vesicle, well-developed pars prostatica, and long protrusible cirrus. Common genital opening preacetabular, behind œsophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed transversely, median, pretesticular, usually behind middle of second fourth of body length, 0.31 to 0.43 by 0.34 to 0.48 millimeter in size; shell gland between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus well developed, occupying space bounded by ovary, acetabulum, and intestinal cæca. Vitellaria in moderately large follicles, commencing anteriorly on both sides at level about midway between posterior border of acetabulum and anterior border of ovary; anteriorly they are extracæcal, but behind second testis the follicles from the two sides unite and occupy most of posterior region of body; transverse vitelline ducts and vitelline reservoir dorsal of shell gland, directly in front of anterior testis. Eggs, numerous, operculated, light brown or yellowish, 85.5 to 101.5 by 54.0 to 65.2 microns in size.

Excretory system typical of echinostomes in general; excretory bladder long, with several small side branches, dividing into two principal branches behind second testis; excretory pore at extreme posterior end of body.

Location.—Small intestine.

Life history.—Unknown. It is most probable, however, from what is known of the life history of mammalian trematodes that the intermediate host is a fresh-water snail. It might be interesting to note moreover that the cercariæ of related flukes assume the infective stage by encysting within their own rediæ or in the tissues of their intermediate hosts; others encyst on plants, fishes, or in tadpoles.

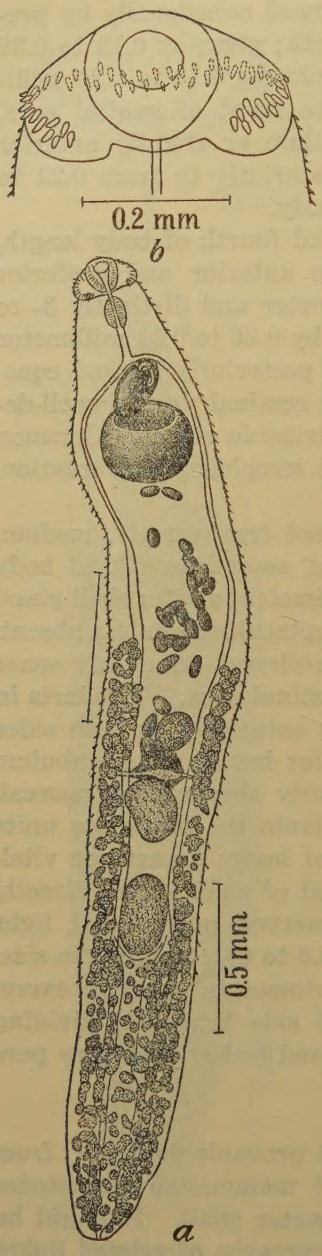

FIG. 2. *Euparyphium guerreroi*. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)

Prevention.—Bearing in mind the possible modes of infestation with this parasite as noted in the discussion of its life history, prevention should consist in the avoidance of raw or improperly cooked vegetables, snails, and fishes and unboiled or unfiltered surface water as food and drink, respectively, especially in those places where the fluke is known to occur.

References.—14, 16, 21, 31, 41, 51, 55.[1]

EUPARYPHIUM GUERREROI Tubangui, 1931. Fig. 2.

Description.—Body slender, elongate, measuring 2.92 to 4.03 millimeters in length by 0.37 to 0.50 millimeter in maximum breadth across acetabulum or anywhere between this organ and anterior testis. Cuticle armed with flat scales, dorsally from anterior end to level of acetabulum and ventrally from anterior end to posterior testis or slightly beyond that level; scales 6.0 to 15.0 by 5.5 to 9.4 microns in size, anterior ones being smaller. Oral sucker small, subterminal, 0.10 to 0.12 millimeter in transverse diameter; acetabulum larger, at middle of anterior third of body length, 0.27 to 0.36 by 0.31 to 0.34 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar (fig. 2, *b*) bearing fifty-five spines arranged in two alternating rows; collar 0.22 to 0.26 millimeter across, reniform, its two ventral angles united by a narrow ridge. Collar spines may be grouped

[1] The numbers refer to the list of references, which are arranged alphabetically and numbered, at the end of this paper.

as follows: Five ventral corner spines on each side of cephalic collar, 24.7 to 31.5 by 9.0 to 11.9 microns; fifteen lateral spines on each side, 27.0 to 29.2 by 9.0 microns; and fifteen dorsal spines, 11.2 to 13.5 by 6.7 to 9.0 microns in size.

Mouth subterminal to terminal, followed by prepharynx 0.03 to 0.07 millimeter long; pharynx 0.10 to 0.11 by 0.07 to 0.08 millimeter in size; œsophagus 0.08 to 0.15 millimeter long, bifurcating in front of level of genital pore; intestinal cæca long, narrow in diameter, reaching from 0.21 to 0.24 millimeter from posterior end of body.

Testes tandem, postequatorial, at third fourth of body length, oval or sausage-shaped, often transversely constricted into anterior and posterior lobes; anterior testis usually smaller, at least shorter, 0.19 to 0.36 by 0.15 to 0.22 millimeter in size; posterior testis 0.27 to 0.39 by 0.12 to 0.20 millimeter in size. Cirrus pouch oval, 0.17 to 0.27 by 0.10 to 0.13 millimeter in size, not reaching posteriorly beyond equator of acetabulum; incloses large seminal vesicle, moderately developed pars prostatica, and protrusible cirrus. Common genital opening preacetabular, behind œsophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed, 0.10 to 0.15 by 0.07 to 0.13 millimeter in size, immediately preëquatorial, pretesticular; shell gland prominent, filling most of the space between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus short, with few coils. Vitellaria in small to moderately large follicles, commencing anteriorly at middle of second fourth of body length, those on left side usually commencing at a more posterior level; behind second testis follicles from two sides unite and extend to posterior end of body; transverse vitelline ducts and vitelline reservoir dorsal of shell gland and immediately in front of first testis. Eggs few, operculated, thin shelled, light brown or yellowish, 78.7 to 85.5 by 54.0 to 60.7 microns in size.

Excretory system of usual echinostome type; excretory bladder long, tubular, dividing into two branches behind second testis; excretory pore at extreme posterior end of body.

Location.—Small intestine.

Life history.—Unknown.

Reference.—55.

EUPARYPHIUM MURINUM sp. nov. Fig. 3.

The description of this parasite is based on the examination of two lots of material. One lot, consisting of a small number of specimens, is part of our collection and was obtained from a

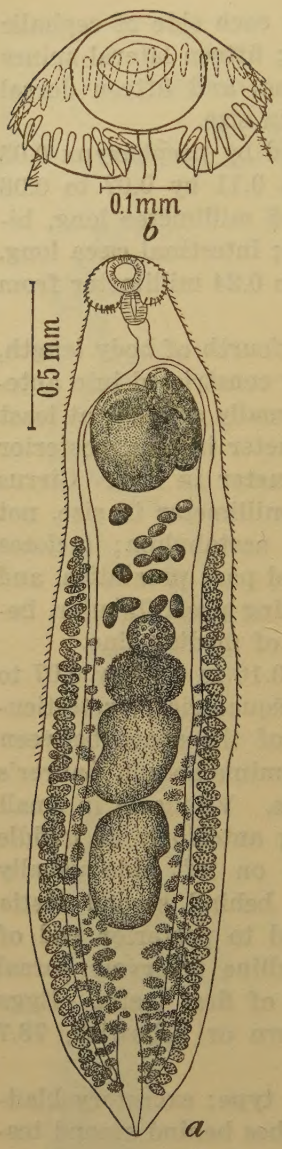

FIG. 3. *Euparyphium murinum* sp. nov. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view.

rat that was at the same time infested with *E. ilocanum*. The other lot consisting of numerous specimens and labelled "parásitos encontrados en el intestino de un ratón, Manila, Agosto, 1909," was collected by Dr. Luis Guerrero. It was kindly turned over to me for determination by Dr. Onofre Garcia who found it among the parasitological collections of the University of Santo Tomas, Manila. I take this opportunity to express my thanks to Doctor Guerrero and Doctor Garcia.

This fluke differs from the two preceding species in the number of its collar spines, of which there are forty-five to forty-six, and in the position of its cirrus pouch that extends posteriorly beyond the equator of the acetabulum. In the number of its collar spines it is similar to *Echinostoma gotoi* Ando and Ozaki, 1923, another rat trematode, but again it may be distinguished from the latter by the position of its cirrus sac and also by the character of its uterus, which is short and contains only a few coils and eggs.

Description.—Body small, elongate, 2.65 to 4.50 by 0.45 to 0.65 millimeters in size. Cuticle armed with flat scales, dorsally from anterior end to acetabulum and ventrally from anterior end to posterior level of first testis or slightly beyond. Oral sucker small, subterminal, 0.10 millimeter in transverse diameter; acetabulum 0.32 to 0.42 by 0.23 to 0.32 millimeter in size, at anterior fourth of body length. Head collar reniform, 0.23 to 0.27 millimeter across, bearing forty-five spines arranged in two alternating rows and measuring 37.5 to 44.2 by

8.0 to 9.2 microns. Occasionally there are forty-six collar spines due to the presence of a small accessory dorsal spine (fig. 3, *b*).

Mouth subterminal; prepharynx absent or very short; pharynx oval, 0.10 to 0.13 by 0.07 to 0.09 millimeter in size; œsophagus 0.07 to 0.12 millimeter long, bifurcating immediately in front of level of genital pore; intestinal cæca long, reaching to near posterior end of body.

Testes tandem, postequatorial, oval to sausage-shaped, with smooth borders or slightly constricted at middle; anterior testis usually smaller, 0.32 to 0.48 by 0.16 to 0.25 millimeter in size; posterior testis 0.33 to 0.53 by 0.15 to 0.26 millimeter. Cirrus pouch oval, 0.25 to 0.36 by 0.10 to 0.13 millimeter in size, usually to one side of median line, dorsal to acetabulum and extending posteriorly beyond the equator of this organ; incloses seminal vesicle, pars prostatica, and protrusible cirrus. Common genital pore immediately preacetabular, a little to one side of median line.

Ovary globular or slightly transversely oval, preëquatorial, pretesticular, 0.10 to 0.15 millimeter in transverse diameter. Shell gland conspicuous, between ovary and first testis. Receptaculum seminis absent, the distal portion of oviduct being dilated and probably functioning as seminal receptacle; Laurer's canal present. Uterus short, with few coils. Vitelline glands in the form of distinct follicles extending from 0.10 to 0.60 millimeter behind acetabular level to near posterior end of body. Eggs few, oval, operculated, thin shelled, yellowish, 88.4 to 95.2 by 57.8 to 61.2 microns in size.

Excretory system of the usual echinostome type; excretory bladder tubular, bifurcating behind second testis; excretory pore at extreme posterior end of body.

Specific diagnosis.—Euparyphium: Body elongate, 2.65 to 4.50 by 0.45 to 0.65 millimeters in size. Head collar 0.23 to 0.27 millimeter in transverse diameter, with forty-five spines measuring 37.5 to 44.2 by 8.0 to 9.2 microns. Prepharynx very short or absent, œsophagus 0.07 to 0.12 millimeter long. Testes oval to sausage-shaped, with smooth borders or slightly constricted at middle; cirrus sac oval, 0.25 to 0.36 by 0.10 to 0.13 millimeter in size, reaching posteriorly beyond equator of acetabulum. Ovary globular or transversely oval, preëquatorial; vitellaria extend from 0.10 to 0.60 millimeter behind acetabular level to posterior end of body. Eggs few, 88.4 to 95.2 by 57.8 to 61.2 microns in size.

Location.—Small intestine.

Locality.—Manila, Philippine Islands.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 64; paratypes in parasitological collection of the University of Santo Tomas, Manila.

Life history.—Unknown.

References.—1, 10, 11, 13, 30, 31, 55.

Class CESTODA Rudolphi, 1808

Subclass CESTODA (s. str.) Monticelli, 1892

Order CYCLOPHYLLIDEA Braun, 1900

Superfamily TÆNIOIDEA Zwicke, 1841

Family TÆNIIDÆ Ludwig, 1886

Subfamily TÆNIINÆ Stiles, 1896

Genus TÆNIA Linnæus, 1758

TÆNIA TÆNIAFORMIS (Batsch, 1786) Wolffhügel, 1911. Fig. 4.

Synonym: *Tænia crassicollis* Rudolphi, 1810.

The larval stage of this tapeworm is commonly known as *Cysticercus fasciolaris* Rudolphi, 1808 (= *Strobilocercus fasciolaris* Sambon, 1924). It is one of the commonest parasites of the brown rat, the livers of 94 per cent of the animals examined being infested with it. The adult stage has so far been found only in cats. Krabbe, according to Stiles (1906), pointed out long ago that in Jütland sandwiches of chopped raw mice were eaten by the common people for the relief of anuria and suggested that this custom might be responsible for the occasional presence of the parasite in man. Thus far, however, no case of the sort has been reported.

Description.—The larvæ are inclosed in globular cysts, partly visible on the surface of the liver of infested rats as whitish semitransparent areas. These cysts are 5 to 16 millimeters in diameter and are easily separated from the hepatic tissue. The larvæ themselves are elongate, measuring 30 to 200 millimeters in length by 2 to 6 millimeters in maximum width near the anterior end. The body (fig. 4, *a*) is strobilate, which character differentiates it from the other bladderworms (*Cysticercus* species), for which reason Sambon (1924) proposed for it the term *Strobilocercus*. In living specimens the anterior portion is usually wider and thicker due to the contraction of

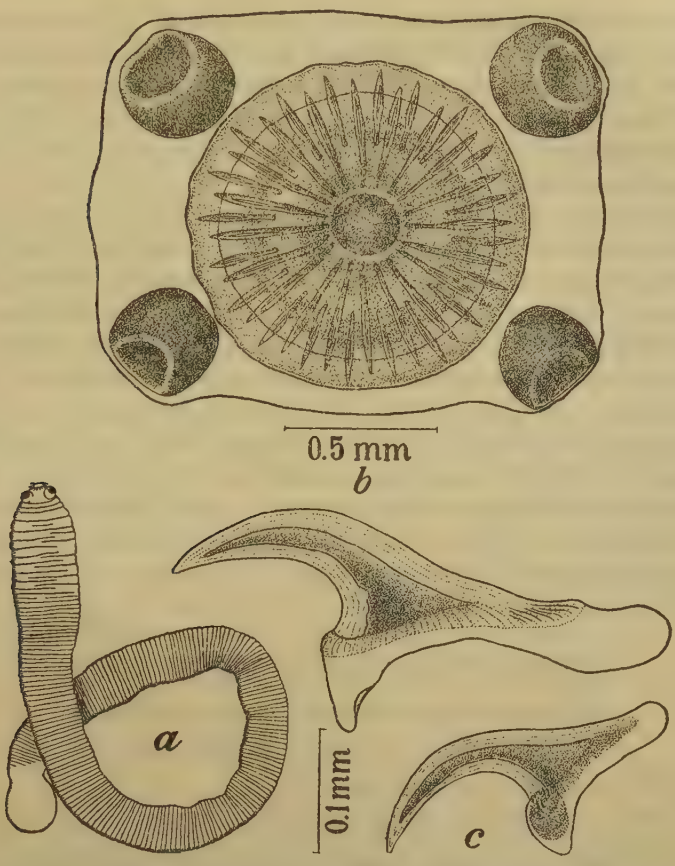

FIG. 4. *Tænia tæniaformis.* *a*, Entire larva (after Sambon, 1924); *b*, scolex, anterior view; *c*, rostellar hooks.

the body at this region and presents a terminal wedge-shaped depression due to the invagination of the scolex. The posterior end is usually more slender, terminating in a very much reduced bladder. Sometimes the segmentation of the body is so distinct and the length so great that this larvæ has been mistaken for a small mature tapeworm. Occasionally rudimentary reproductive organs are present among some of the segments. The scolex (fig. 4, *b*) is large, thick, 1.3 to 1.7 millimeters broad; suckers prominent, cup-shaped, 0.32 to 0.38 millimeter in diameter; rostellum short, columnar, 1.12 to 1.14 millimeter in diameter, crowned with 26 to 52 hooks, according to various authors (hooks of Philippine material 38 to 42). The hooks (fig. 4, *c*) are of the characteristic shape found in the group of tapeworms

to which this parasite belongs and are arranged in two concentric circles; those forming the upper row are larger, 380 to 420 microns long, their free pointed ends being almost on a line with those of the shorter hooks of the lower ring with which they alternate; the smaller hooks are 250 to 270 microns long.

Location.—Liver.

Life history.—The encysted strobilocercus in the liver of rats and other rodents represents the infective stage in the transmission of this parasite to its final host. If fed to a cat, the larva is liberated in the small intestine, attaches itself to the intestinal wall, increases in size, and, after two to three months, becomes mature. The eggs of the adult parasite escape with the fæces of the host and, if these are ingested by a rat or any other animal that can play the rôle of intermediate host, the inclosed embryos are freed from their shells in the intestine. These embryos on reaching the liver become encysted and are developed into strobilocerci. They reach the liver presumably through the circulatory system after penetrating through the intestinal wall.

References.—20, 27, 37, 49.

Family DAVAINEIDÆ Fuhrmann, 1907

Subfamily DAVAINEINÆ Braun, 1900

Genus RAILLIETINA Fuhrmann, 1920

RAILLIETINA GARRISONI sp. nov. Fig. 5.

Synonym: ? *Davainea madagascariensis* (Davaine) of Garrison, 1911.

This appears to be the commonest intestinal cestode infesting the brown rat in the Philippines. It bears a close resemblance to *R. celebensis,* but differs from the latter, as described by Janicki (1902) and by Meggitt and Subramanian (1927), in having a larger number of testes and uterine egg capsules and in the larger size of its cirrus pouch. It is, therefore, proposed as a new species and is named *Raillietina garrisoni* in honor of the late Dr. P. E. Garrison.

The parasite deserves more than passing notice due to its possible identity with *Davainea madagascariensis* (Davaine) of Garrison, 1911, which was collected at autopsy by Dr. Vernon L. Andrews from the small intestine of a male adult Filipino in Manila. According to Joyeux and Baer (1929) Garrison's material differs in the size of its rostellar hooks and of the cirrus pouch from the types described under the same name by other observers, and it is, therefore, likely that it represents another

species. According to the same authors it is allied to *R. celebensis* but differs from the latter in the size of its cirrus sac and in the number of its testes, which characters, it will be recalled, are the very ones that distinguish *R. garrisoni* from *R. celebensis*.

Joyeux and Baer are of the opinion that Garrison's *Davainea madagascariensis* and other rare human cestodes are parasites of wild animals that are accidentally transmitted to man. They suggest as one way of establishing the identity of these parasites the systematic collection and determination of the tapeworms of wild animals that habitually come in close contact with human beings in countries where such parasites have been recorded. The survey on which this report is based was, therefore, in line with the suggestion of the French authors and it is here shown that there exist important similarities in the morphology of *R. garrisoni* and of *D. madagascariensis* as described by Garrison (Table 2). In view of this and in view of the common occurrence of *R. garrisoni* in rats, a number of the parasites of which are transmissible to man, it is quite probable that Garrisons's tapeworm is identical with this species.

TABLE 2.—*Comparison between Raillietina garrisoni sp. nov. and Davainea madagascariensis (Davaine) of Garrison, 1911.*

	D. madagascariensis.	*R. garrisoni.*
Total length——mm	390	Up to 600.
Size of terminal gravid segments——do	2.0–2.5×1.0–1.5	1.60–2.12×1.05–1.40.
Diameter of head——do	0.32–0.40	0.40–0.80.
Diameter of sucker——do	0.105–0.125	0.10–0.15.
Number of rostellar hooks		90–140.
Length of rostellar hooks——μ	23.5–25.2	20–26.
Number of testes	50	36–50.
Size of cirrus sac——mm	0.12–0.16×0.064–0.100	0.13–0.18×0.054–0.085.
Position of genital pores	Normally unilateral; anterior.	Normally unilateral; anterior.
Diameter of uterine egg capsule——mm	0.20–0.40	0.06–0.15 (measured from mounted specimens).
Number of eggs per egg capsule	1–3; generally 2	1–4; generally 3.
Size of eggs with elongated shell intact——μ	50–64×19–23	52–80×22–26.
Length of embryonal hooks——μ	4–5	4–6.

Description.—Total length up to 600 millimeters, the maximum breadth in the region of mature proglottids. Head (fig. 5, *b*) subglobular, 0.40 to 0.80 millimeter in diameter; suckers unarmed, 0.10 to 0.15 millimeter in diameter; rostellum 0.13 to

0.18 millimeter in diameter, armed with 90 to 140 hammer-shaped hooks (fig. 5, *a*) that are 20 to 26 microns in length and arranged in two alternating circular rows; rostellum with a spiny collar, the spines being comma-shaped and averaging about 5 microns long. Neck short, 0.28 to 0.36 millimeter in width. Segments broader than long except at posterior end where gravid proglottids may be nearly twice as long as wide (fig. 5, *d*); immature segments 0.08 to 0.17 millimeter long by 0.30 to 0.60 millimeter wide, mature segments 0.43 to 0.65 by 1.40 to 1.65 millimeters, and gravid segments 0.95 to 2.12 by 0.15 to 1.40 millimeters. Genital pores normally unilateral and dextral, situated near anterior extremity of lateral border of segments.

Main portion of excretory system represented by two pairs of lateral longitudinal vessels, ventral and dorsal; ventral pair more lateral in position, larger in diameter and connected in the posterior part of each segment by transverse canal; dorsal vessels small and with no transverse canals. Peripheral nervous system represented by a longitudinal nerve on each side, at middle between ventral excretory vessels and lateral margins of proglottids. Muscular system feebly developed and arranged as in other cestodes; consists of minute longitudinal and transverse fibers located immediately beneath cuticle and of longitudinal, transverse and dorsoventral fibers in parenchyma, of which the longitudinal and dorsoventral ones are most conspicuous.

Testes (fig. 5, *c*) small, roundish, 40 to 50 microns in diameter, confined within parenchyma between excretory vessels, 36 to 50 in number, of which 9 to 15 are on the poral side of the median line and 26 to 35 aporal. Vas deferens a long, much-convoluted tube near anterior border of segment, running almost transversely from median line to cirrus sac, passing with corresponding vagina between excretory vessels and ventral to longitudinal nerve. Cirrus sac distinctly gourd-shaped, 0.13 to 0.18 by 0.054 to 0.085 millimeter in size, extending either transversely or a little obliquely towards cephalic end from genital pore to longitudinal nerve.

Ovary (fig. 5, *c*) median, bilobed, each lobe being oval, with smooth surface and measuring 0.12 to 0.15 by 0.08 to 0.10 millimeter. Vagina a narrow canal, posterior to vas deferens and cirrus pouch, running transversely from median line to genital pore; before opening into genital pore it is usually slightly dilated to form a small receptaculum seminis. Near the median

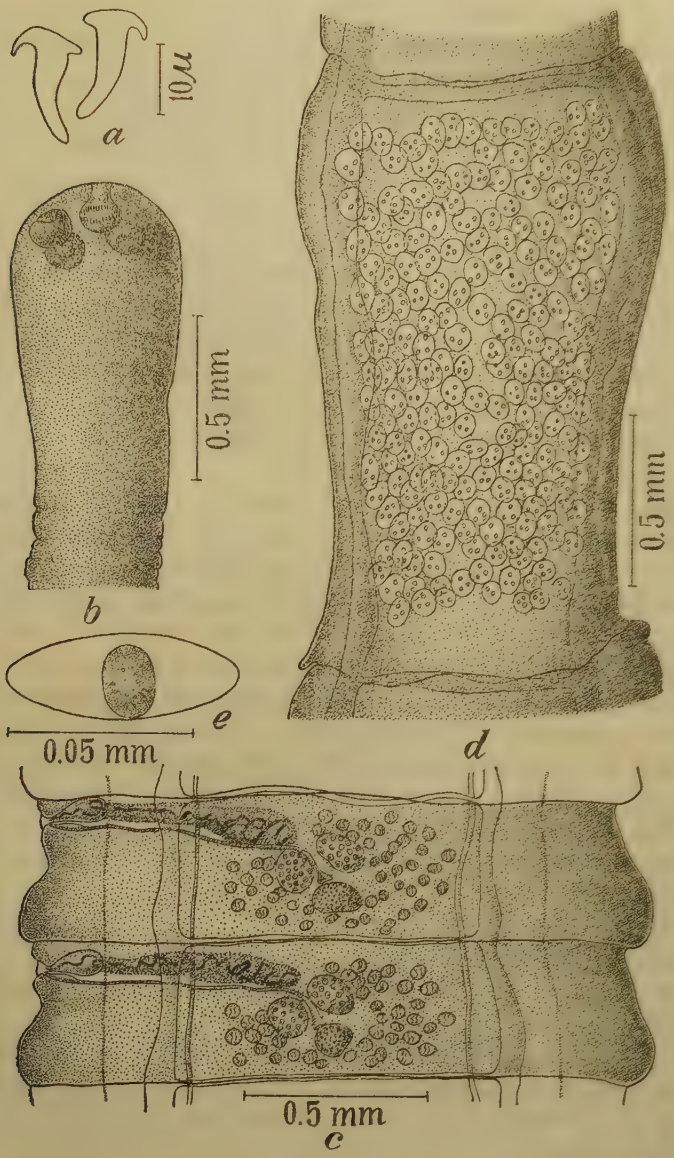

FIG. 5. *Raillietina garrisoni* sp. nov. *a*, Rostellar hooks; *b*, scolex; *c*, mature segment; *d*, gravid segment; *e*, egg.

line the vagina bends posteriorly and joins the oviduct, forming a slightly dilated tube, the oötype complex, between ovary and vitelline gland. Vitelline gland roundish to oval, immediately posterior to ovary, and measuring 0.09 to 0.13 millimeter across.

Uterus at first a simple sac filled with immature ova; in fully developed gravid segments it breaks down into numerous egg capsules, each containing 1 to 4, but mostly 3, eggs. Egg capsules (fig. 5, *d*) 0.06 to 0.15 millimeter in diameter, confined within excretory vessels, although a few of them may be found lateral to these canals, and numbering 180 to 200 in anterior gravid segments and 300 to 400 in elongated posterior gravid proglottids. Eggs (fig. 5, *c*) of characteristic shape, the onchosphere surrounded by two thin membranes: outer membrane elongated oval, 52 to 80 by 22 to 26 microns in size; inner membrane usually closely applied around onchosphere, round, 18 to 22 microns in diameter in fresh specimens; between inner and outer membranes a few connecting strands or fibers are sometimes present; onchosphere supplied with three pairs of embryonal hooks 4 to 6 microns long.

Specific diagnosis.—Raillietina: Length up to 600 millimeters, maximum breadth 1.4 millimeters. Head 0.40 to 0.80 millimeter in diameter; rostellum 0.13 to 0.18 millimeter in diameter, with 90 to 140 hooks 20 to 26 microns long; a spiny collar posterior to rostellum present, the spines being comma-shaped and about 5 microns long. Suckers unarmed, 0.10 to 0.15 millimeter in diameter. Genital pores normally unilateral and dextral, near anterior extremity of lateral border of segments. Cirrus sac 0.13 to 0.18 by 0.054 to 0.085 millimeter in size, extending only up to nerve. Testes 9 to 15 poral, 26 to 35 aporal, total 36 to 50. Egg capsules 180 to 400, each containing 1 to 4, generally 3, eggs; found mostly within excretory vessels, but a few lateral to them.

Location.—Small intestine.

Locality.—Manila, Philippine Islands.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 12.

Life history.—Unknown. Probably similar to the mode of development of most tapeworms, and in particular to other species of *Raillietina,* which utilize as intermediate hosts various forms of insects.

Prevention.—Due to reasons given above, this tapeworm may be looked upon with suspicion as one of those parasites of rats that are transmissible to man. Since the life history has not yet been worked out, however, no definite prophylactic measures can be given except to advocate the destruction of rats and mice, the proper disposal of the stools of infected persons, and the

practice of all-around cleanliness, by means of which all parasitic infestations can be avoided.

References.—17, 22, 25, 27.

Family HYMENOLEPIDIDÆ Railliet and Henry, 1909

Subfamily HYMENOLEPIDINÆ Ransom, 1909

Genus HYMENOLEPIS Weinland, 1858

HYMENOLEPIS DIMINUTA (Rudolphi, 1819) Blanchard, 1891. Fig. 6.

Synonyms: *Tænia diminuta* Rudolphi, 1819; *Hymenolepis flavopunctata* Weinland, 1858; *Tænia flavomaculata* Leuckart, 1863.

This common tapeworm of rats was first reported in man by Weinland in 1858. Since that time up to 1922, according to Riley and Shannon (1922), a total of sixty-one cases of human infestations with this parasite have been recorded from various parts of the world. To these should be added the one case detected by Schwartz and Tubangui (1922) in a native Filipino, the twenty Indian cases found by Chandler (1927), and the single case recently reported by Spindler (1929) from the United States.

Description.—Strobila composed of 800 to 1,300 proglottids; length 100 to 600 millimeters, depending upon number of proglottids; maximum width at posterior end in region of gravid segments, 2.5 to 4.0 millimeters. Head (fig. 6, *a*) almost globular, 0.20 to 0.60 millimeter broad; rostellum rudimentary, pyriform, without hooks; suckers globular, near apical portion of head, 0.08 to 0.16 millimeter in diameter. Neck short. Segments wider than long; immature segments 0.045 to 0.200 by 0.305 to 0.835 millimeter in size, mature segments 0.238 to 0.380 by 0.084 to 1.670 millimeters, and gravid segments 0.305 to 0.684 by 1.805 to 3.115 millimeters. Posterior border of segments only slightly wider than anterior borders, for which reason serration of strobila not as marked as in other cestodes. Genital pores usually unilateral and sinistral, at middle or at anterior third of lateral margins of proglottids. Main portion of excretory system consists of two pairs of lateral longitudinal vessels: a larger ventral pair connected in the posterior part of each segment by a transverse canal and a smaller dorsal pair with apparently no cross-connectives; the terminals of the ventral and dorsal vessels of one side are united in the region of the head. Muscular system fairly well developed, consisting of circular and longitudinal subcuticular fibers and another set of

longitudinal, transverse, and dorsoventral muscle fibers in the parenchyma.

Normally there are three testes in each mature segment—one poral and two aporal— arranged, more or less, in a straight line across segment and separated by ovary (fig. 6, *b*). Occasionally this arrangement is reversed; that is, there are two testes on the poral side of the ovary and one on the aporal side. Exceptionally, the two aporal testes are placed obliquely or one behind the other. In some segments, instead of the usual three testes, there may be only two, or there may be four to six. The testes are spherical, 0.12 to 0.14 millimeter in diameter. The vas deferens before entering the cirrus pouch is dilated to form a prominent seminal vesicle. Cirrus sac 0.17 to 0.30 by 0.02 to 0.04 millimeter in size in mature segment, 0.24 to 0.40 by 0.04 to 0.06 millimeter in gravid segments, extending from genital pore to or just past excretory vessels; incloses slender, protrusible cirrus.

Ovary bilobed, 0.35 to 0.40 millimeter across, median, intertesticular; surface indented to form small lobules. Vitelline gland lenticular in shape, immediately postovarial. Shell gland small, rounded, between ovary and vitelline gland. Receptaculum seminis large, prominent, extending transversely from median line to excretory vessels; it then becomes narrow in diameter and is continued as the vagina. The latter leads to the common genital pore, passing ventral and slightly posterior to the cirrus pouch. Uterus in pregravid segments in the form of a transversely elongated and apparently solid mass of cells representing young undeveloped ova; it soon becomes hollowed out, sending diverticula in all directions, and in the fully developed state it has the appearance of a sac incompletely divided by partitions into egg capsules and occupying nearly the entire space within a gravid segment (fig. 6, *c*). Mature eggs (fig. 6, *d*) spherical or slightly oval, the embryo proper or onchosphere being surrounded by three membranes, as follows: A thicker, very faintly radially striated outer membrane, 54 to 86 microns in diameter; a thinner envelope immediately surrounding embryo, oval in shape, 24 by 20 to 40 by 35 microns in size, often with two polar projections but without filaments as is the case with the eggs *Hymenolepis nana;* and an intermediate layer between outer and inner membranes, apparently composed of albuminous substance and often appearing as two delicate smooth membranes with intervening space filled by

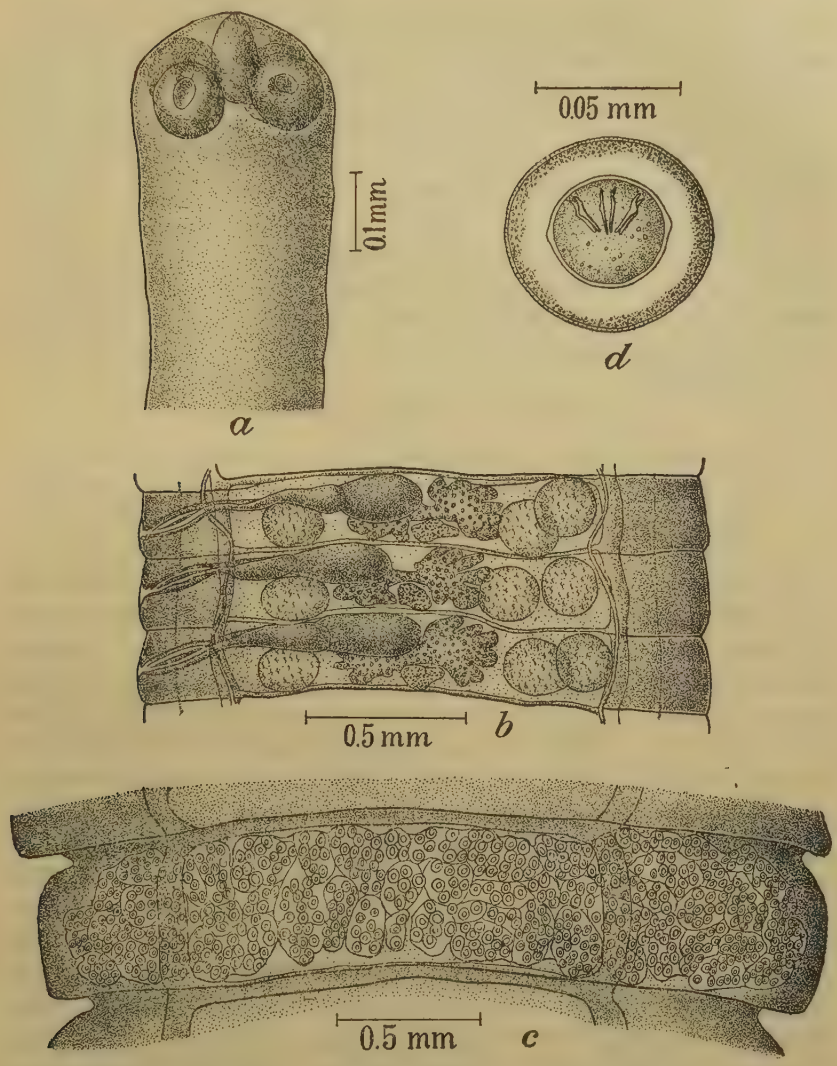

FIG. 6. *Hymenolepis diminuta*. *a*, Head; *b*, mature segment, dorsal view; *c*, gravid segment; *d*, egg.

granular substance. Embryonal hooks 10 to 16 microns in length.

Location.—Small intestine.

Life history.—Involves an intermediate host. If ingested by any of the following insects, the eggs will develop into infectious larvæ known as cysticercoids: Meal moth (*Anisopia farinalis*), earwig (*Anisolabis annulipes*), beetles (*Akis spinosa, Scaurus*

striatus and *Tenebrio molitor*), cockroaches (*Blatta orientalis* and *Phyllodromia germanica*), and rat fleas (*Ceratophyllus fasciatus* and *Xenopsylla cheopis*). The cysticercoids are found either free in, or encysted in the adipose tissue of, the abdominal cavities of the above insects. Rats as well as human beings become infected by ingesting these cysticercoids together with any of the above intermediate hosts.

Prevention.—Consists in the avoidance of rats and mice in houses, in the destruction of beetles, cockroaches, and other insects that act as intermediate hosts, in the protection of foods from such insects, and in the proper disposal of the stools of infected persons.

References.—8, 14, 25, 27, 33, 35, 40, 48, 49, 51.

HYMENOLEPIS NANA (Siebold, 1852) Blanchard, 1891. Figs. 7 and 8.

Synonyms: *Tænia murina* Dujardin, 1845; *Tænia ægyptiaca* Bilharz, 1852; *Hymenolepis fraterna* Stiles, 1906; *Hymenolepis longior* Baylis, 1922.

As indicated by its name (*nana*, or dwarf) one of the distinguishing characteristics of this cestode is its small size; hence it is commonly known as the dwarf tapeworm. It is a common parasite of rats and mice and of human beings in many parts of the world, especially in tropical and subtropical countries. Opinion, however, is divided on the identity of the dwarf tapeworm of rats and mice with the form found in man. Some consider the two forms as representing one and the same parasite (*vide* Woodland, 1924), while others believe that they are distinct (*vide* Joyeux, 1925). If the latter opinion should prove to be true, the rodent parasite would have to be designated as *Hymenolepis fraterna* Stiles, 1906, the older name, *Tænia murina* Dujardin, 1845, being preoccupied and, therefore, not available. The designation *nana* would then apply only to the human form. The present writer believes with Stiles (1906) that " from a standpoint of prevention they should at present be considered as identical," which opinion has been justified by the successful cross-infection experiments of Saeki (1920) and Woodland (1924) as well as by the recent epidemiological observations of Chandler (1927). The latter investigator concluded from his observations that rats are an important epidemiological factor in the dissemination of *H. nana*, for he found the distribution of the parasite in human beings in India to correspond very closely with that of another rat-borne disease; namely, bubonic plague.

The occurrence of this parasite in human beings in the Philippines has been recorded by Riley (1919), who found it in a

fæcal sample obtained from an American Bohemian child residing in Zamboanga, Mindanao, and forwarded to him by Dr. A. F. Coutant. The child was one of a family of five and it appears from the data furnished by the sender that the other members of the family were similarly infested with the worm in question. Among the files of the Bureau of Science for 1928 on the results of the routine examination of fæcal specimens submitted by the Philippine Health Service for evidences of intestinal parasitism, there is also an unpublished record of its presence in a young Chinese boy living in Manila. In Philippine rats, on the other hand, this is the first report of its occurrence, and it seems that it is rare in these animals, for it was found in only 1.7 per cent of the total number of rats examined.

Description.—Strobila composed of 96 to 840 proglottids; length 5 to 90 millimeters, depending upon number of segments; maximum width 0.20 to 0.90 millimeter, near posterior end. Head (fig. 8, *a*) subglobular, 0.13 to 0.48 millimeter in diameter; suckers globular, 0.07 to 0.15 millimeter in diameter; rostellum well developed, freely movable, armed near its anterior end with 20 to 30 characteristic hooks (fig. 7, *b*); latter 14 to 18 microns in length, with curved dorsal root directed anteriorly on rostellum and, directed posteriorly, a thick ventral root about equal in length to a sharp pointed prong with which it forms a sort of fork. Neck slender, 0.08 to 0.10 millimeter in length by 0.08 to 0.30 millimeter in width. Anterior segments very short; following segments increase in length and breadth but remain broader than long; most posterior segments, however, may be occasionally stretched and be as long as wide or even longer than wide. Measurements on Philippine material as follows: Immature segments 0.02 to 0.03 millimeter long by 0.14 to 0.17 millimeter wide, mature segments 0.04 to 0.08 by 0.17 to 0.32 millimeter, gravid segments 0.08 to 0.12 by 0.30 to 0.37 millime-

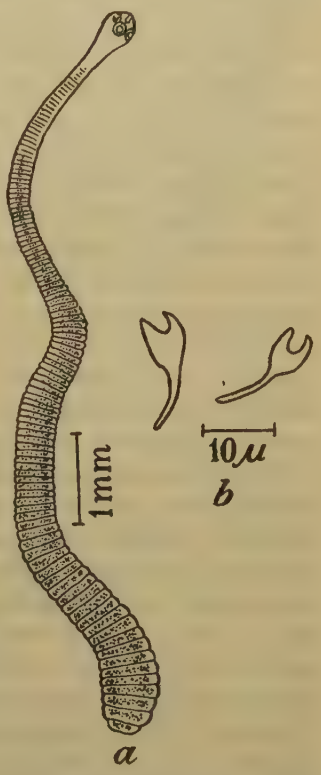

FIG. 7. *Hymenolepis nana*. *a*, Entire worm (from Ransom, 1904); *b*, rostellar hooks.

ter. Genital pores generally all on left side, near anterior border of segments.

Main portion of excretory system consists of two pairs of lateral longitudinal excretory vessels: a small dorsal pair and a larger ventral pair of vessels, the latter united in the posterior portion of each segment by a transverse canal; ventral and dorsal vessels of one side united in the region of the scolex and form an anastomosis at the base of the rostellum. Peripheral nervous system represented by a pair of longitudinal nerves, one on each side of strobila, lateral to excretory vessels. Muscular system weakly developed, consisting of outer circular and inner longitudinal subcuticular fibers and of longitudinal fibers in parenchyma; transverse and dorsoventral parenchymal fibers may also be present, but very few and weakly developed.

Three testes in each mature segment (fig. 8, *b*), normally one on left and two on right side of median line and usually arranged in more or less straight transverse line at posterior portion of proglottids; the arrangement, position, and number of these organs, however, are liable to variation as in *Hymenolepis diminuta;* they are globular, 28 to 34 microns in diameter. Vas deferens a slender canal for the most part; before entering cirrus pouch it may be dilated to form a small seminal reservoir; within cirrus pouch it may also be enlarged to form a seminal vesicle. Cirrus pouch club-shaped, 0.065 to 0.072 by 0.018 to 0.021 millimeter in size, its long axis directed transversely or sometimes obliquely forwards from genital pore to excretory vessels, passing dorsal to longitudinal nerve.

Ovary transversely elongated, bilobed, 0.10 to 0.12 millimeter across, lying ventral to testes. Vitelline gland rounded to oval in shape, immediately postovarial. Shell gland very small, between ovary and vitelline gland. Receptaculum seminis large, prominent, extending transversely from median line to excretory vessels; it then becomes narrow in diameter and is continued as the vagina. Latter leads to common genital pore, passing between cirrus pouch and excretory vessels and nerve. Uterus at first a transversely elongated cellular mass in front of ovary; it soon hollows out and assumes in the oldest segments the form of a sac containing many infoldings or incomplete partitions (fig. 8, *c*); it is more or less completely filled with eggs numbering 80 to 180 in each gravid segment. Eggs (fig. 8, *d*) oval or globular, with two distinct membranes separated by an intervening space containing a finely granular transparent sub-

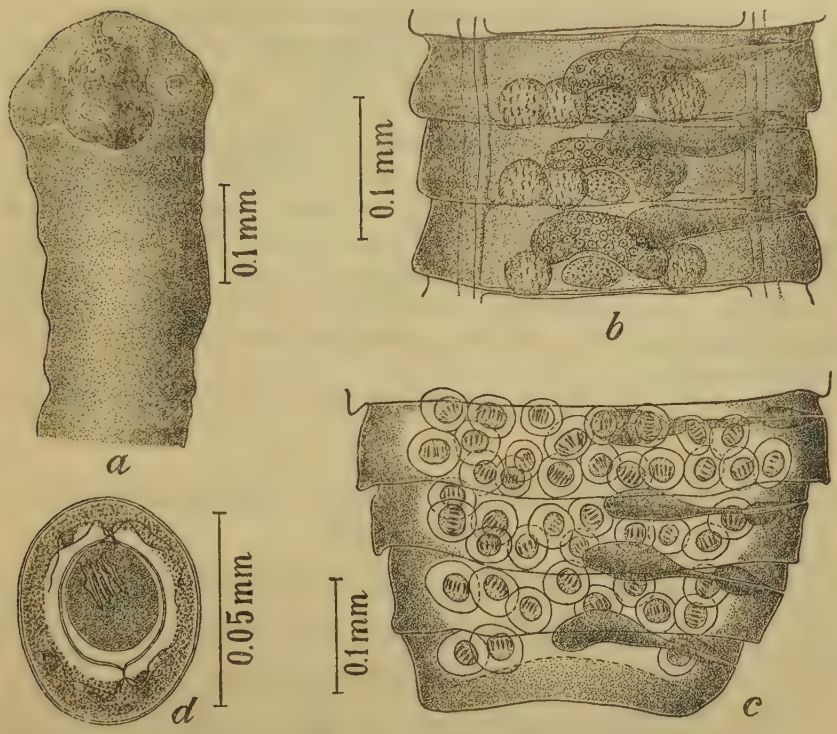

FIG. 8. *Hymenolepis nana.* *a*, Head; *b*, mature segment, ventral view; *c*, gravid segment; *d*, egg.

stance; outer egg membrane, according to various authors, 30 to 60 microns in diameter; inner membrane 16 to 34 microns in diameter, usually with more or less conspicuous mammillate projection at each pole and filamentous appendages; embryonal hooks 10 to 14 microns long. (Measurements of eggs of Philippine material as follow: Outer membrane 45 to 60 by 34 to 51 microns, inner membrane 30 to 34 by 23.5 to 27.2 microns.)

Location.—Small intestine.

Life history.—This parasite is unique among the other cestodes in that it has a one-host life-cycle; that is, it is capable of completing its development from egg to adult in a single individual host. This peculiar life history was first demonstrated by Grassi (1887) and has subsequently been confirmed by the more recent studies of Joyeux (1920), Woodland (1924), and others.

The mature eggs (onchospheres) are discharged with the fæces of an infested animal. If swallowed by a proper host

(for example, a rat), the inclosed embryos become free in the intestinal tract and develop into cysticercoids within the intestinal villi. The cysticercoids then reënter the alimentary canal where they grow into adult tapeworms.

Prevention.—Avoid rats and mice in houses; keep foods out of the reach of rats and mice, especially foods that are eaten raw, or after cooking are kept for some time before being eaten; avoid introducing into the mouth dirty and unnecessary objects that are apt to be contaminated with the eggs of the parasite. Infested persons should observe strict personal cleanliness, especially after defecation and their stools should be properly disposed of.

References.—8, 14, 18, 23, 24, 25, 27, 33, 36, 48, 49, 51, 58, 59.

Phylum NEMATHELMINTHES Vogt (quoted by Carus, 1863)

Class NEMATODA Rudolphi, emend. Diesing, 1861

Order EUNEMATODA Ward, 1916

Superfamily RHABDIASOIDEA Railliet, 1916

Family RHABDIASIDÆ Railliet, 1915

Genus STRONGYLOIDES Grassi, 1879

STRONGYLOIDES RATTI Sandground, 1925, fig. 9.

Synonym: *Strongyloides papillosus* (Wedl, 1856) Hall, 1916.

This minute worm was found in scrapings from the mucous membrane of the small intestine of 74 per cent of the rats examined. In a large number of the cases it was associated with *Nippostrongylus muris*. As indicated by Sandground (1925), it may be distinguished from *S. papillosus* (Wedl, 1856) of sheep, goats, and rabbits, with which it has been confused, by its smaller size, the finer striations of its cuticula, and the course of its ovaries.

Description.—Parasitic generation, represented by females, 2.20 to 2.75 millimeters long by 30 to 35 microns thick. Body filiform, attenuated anteriorly; posterior end behind anus suddenly tapers into a short pointed tail. Cuticle finely striate. Mouth surrounded by three minute papillæ; leads directly to œsophagus. Œsophagus 0.70 to 0.78 millimeter long, gradually increasing in diameter posteriorly. Excretory pore 0.10 to 0.12

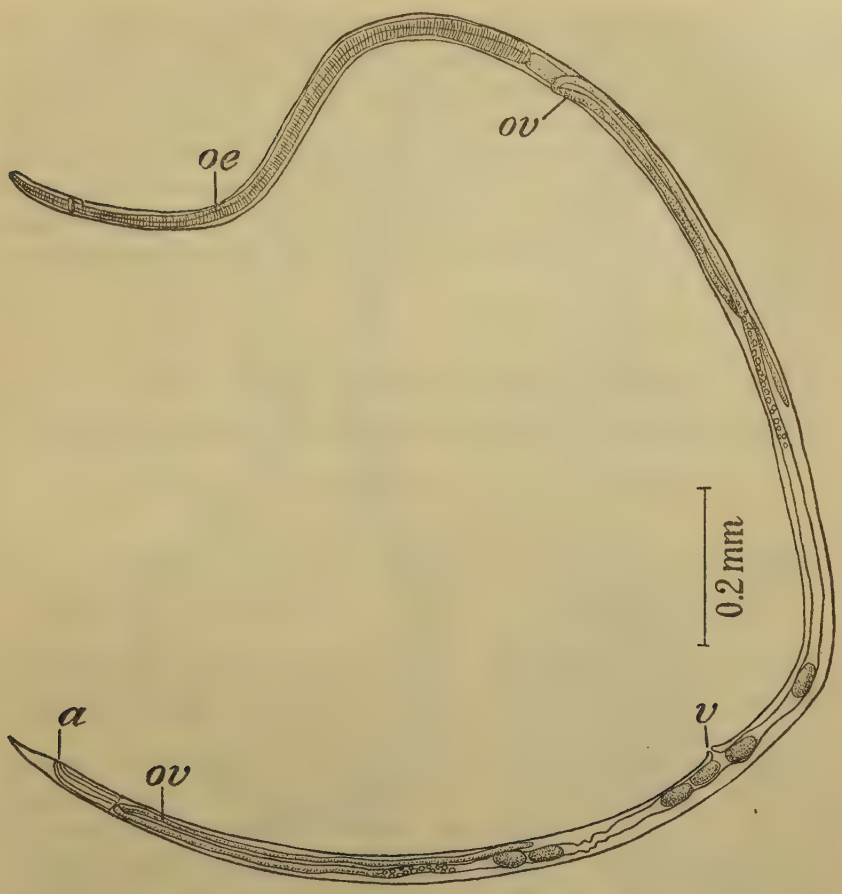

FIG. 9. *Strongyloides ratti*, entire worm. *a*, Anus; *oe*, œsophagus; *ov*, ovary; *v*, vulva.

millimeter from anterior end. Nerve ring immediately in front of excretory pore. Anus 42 to 45 microns from posterior end. Vulva with prominent lips, 1.70 to 1.82 millimeters from anterior end. Ovaries directly recurrent, their bends being close to œsophageal and anal ends of digestive tract; each is continued as oviduct, then as uterus, so that uteri are divergent. Eggs few in number (maximum 10 or 11 in both uteri), 51 to 56 by 27 to 29 microns in size (according to Sandground, 47 to 52 by 28 to 31 microns); they contain larvæ at deposition.

Location.—Small intestine.

Life history.—As shown by Sandground (1926), the life history is very similar to that of *Strongyloides stercoralis* of man. The eggs hatch while still in the small intestine of the host

and the liberated, actively motile, rhabditiform embryos are passed with the fæces. These may either develop immediately into filariform larvæ that are capable of infesting new hosts or become mature free-living males and females that copulate and produce eggs, from which free-living rhabditiform larvæ are hatched. The latter are then transformed into infective filariform larvæ. Infestation is usually through the skin, the filariform larvæ being capable of boring through the integument of the host.

References.—7, 19, 38, 63.

Superfamily TRICHUROIDEA Railliet, 1916

Family TRICHOSOMOIDIDÆ Yorke and Maplestone, 1926

Subfamily TRICHOSOMOIDINÆ Hall, 1916

Genus TRICHOSOMOIDES Railliet, 1895

TRICHOSOMOIDES CRASSICAUDA (Bellingham, 1840) Railliet, 1895. Fig. 10.

Synonyms: *Trichosoma crassicauda* Bellingham, 1840; *Trichosoma muris decumani* Rayer, 1843.

Description.—Marked sexual dimorphism: male much smaller than, and usually parasitic in vagina or uterus of, female (fig. 10, *a*). Anus posteroterminal in both sexes.

Male 1.60 to 5.20 millimeters in length by 19 to 40 microns in maximum width, according to various authors. Body threadlike, not distinctly divided into slender anterior and enlarged posterior portions. Cuticle very finely striated transversely. Anterior end (fig. 10, *b*) with terminal stylet and prepucelike cuticular sheath, according to Thomas (1924). Œsophagus 0.70 to 1.28 millimeters long or about one-half to one-third of total body length. Testis single, tubular, originating from anterior region of body and extending to near posterior end, where it is transformed into a small seminal vesicle. Spicule, bursa, or copulatory organs of any sort absent.

Female 10.5 to 14.6 millimeters in length by 0.175 to 0.200 millimeter in maximum thickness near posterior end. Body covered with transverse cuticular ridges except at extreme anterior end; it is divided into a slender anterior portion, corresponding to length of œsophagus, and into a thicker posterior portion occupied by intestine and reproductive organs. Head rounded, 20

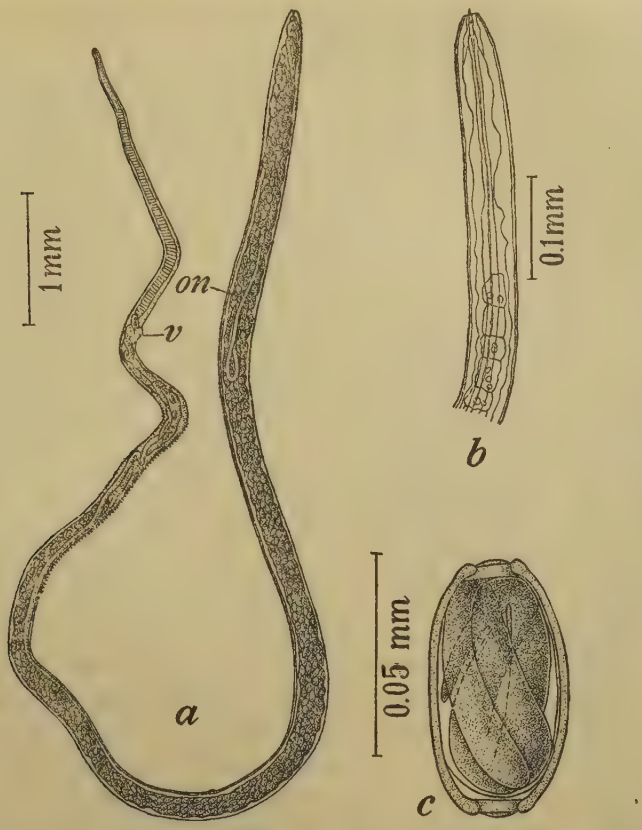

FIG. 10. *Trichosomoides crassicauda.* *a*, Mature female with male in uterus (after Hall, 1916), *m*, male worm; *v*, vulva; *b*, anterior end of mature male (after Thomas, 1924); *c*, egg.

to 22 microns in diameter. Mouth simple, minute. Œsophagus a capillary tube, 1.50 to 1.90 millimeters long, which is equal to between one-sixth and one-eighth of total body length; most of the anterior portion of œsophagus apparently free of surrounding cells, the rest passing through a chain of large œsophageal cells. Vulva ventral, immediately behind œsophageal termination. Vagina long, thin-walled, directed posteriorly, distinguised from uterus by presence of dark brown eggs. Uterus reaches to near posterior end of body. Eggs (fig. 10, *c*) generally oval but may be subspherical or cylindrical, thickshelled, plugged at both poles, embryonated at deposition, 61.2 to 72.0 by 25.0 to

56.0 microns in size. They are colorless in the uterus, but in the vagina they become dark brown.

Location.—Urinary bladder; also renal pelvis and ureters.

Life history.—Simple and direct. If ingested by the proper host, the eggs, which contain well-developed embryos when oviposited and which are passed out with the urine of an infected animal, hatch in the stomach of the host. The newly-hatched larvæ measure 264 to 390 microns in length by 10 to 16 microns in maximum width and are provided with a terminal stylet and a prepucelike fold at the anterior end. After boring out through the wall of the digestive tract these larvæ enter the blood stream and are carried to the heart by way of the portal system. According to Yokogawa (1921), they have to pass through the lungs before they can establish themselves in their normal habitat. The experiments of Thomas (1924), however, do not indicate that passage through the lungs is absolutely essential in the development of this parasite in the same sense that *Ascaris* larvæ, for example, must go through these organs before they can become adults. According to Thomas, the larvæ of *Trichosomoides crassicauda* are dispersed by the circulatory system to different parts of the body, but only those that become lodged in the urinary tract are able to complete their development. The adult state is reached in three to six weeks after the ingestion of the eggs. Copulation takes place at any point in the urinary tract. The male enters the vagina of the female and may either remain there permanently or wander out again.

References.—19, 52, 61, 63.

Family TRICHURIDÆ Railliet, 1915

Subfamily CAPILLARIINÆ Railliet, 1915

Genus HEPATICOLA Hall, 1916

HEPATICOLA HEPATICA (Bancroft, 1893) Hall, 1916. Fig. 11.

This appears to be one of the commonest parasites of the brown rat in the Philippines, about 90 per cent of the rat livers examined showing the presence of irregular white or yellowish spots that mark the presence of the worm's eggs. It is at the same time one of those helminths that are able to establish themselves in a variety of hosts other than rats and mice. It has been reported from the European hare (*Lepus europus*), the rabbit, and the prairie dog (*Cynomys ludovicianus*). The guinea pig, dog, and monkey are also susceptible to

it. In man the first and, up to the present time, the only report of its occurrence is that by Dive and Lafrenais (1924), who recovered the parasite from a British soldier who lived for three years in India. At autopsy the subject presented a liver abscess, in the proximity of which were masses of the parasite's eggs; the worms themselves were found in the periphery of the abscess.

Description.—Body capillary divided into anterior œsophageal and posterior portions. Cuticle delicately striate, apparently without bacillary band. Mouth simple. Worms, both male and female, 40 to 50 millimeters long.

Male 28 microns thick at posterior end; anterior and posterior portions of body about equal in length. Spicule absent, but represented by membranous sheath prolonged from posterior extremity.

Female 100 to 120 microns thick at middle of body and 65 microns at tail. Anterior portion of body about half as long as posterior portion. Vulva (fig. 11, *a*) prominent, 6 to 7 millimeters from anterior end, opening at level of posterior œsophageal region. Tail very short, blunt and conical. Oviparous; eggs lemon-shaped, double walled, 54 to 58 by 32 to 34 microns in size, plugged at each pole (fig. 11, *b*); outer eggshell striate, inner shell homogeneous.

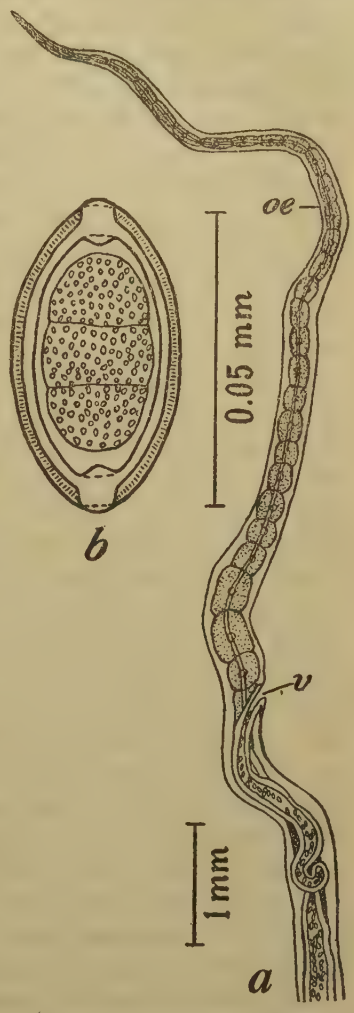

FIG. 11. *Hepaticola hepatica*. *a*, Anterior end of mature female (after Nishigori, from Yorke and Maplestone, 1926); *oe*, œsophagus; *v*, vulva; *b*, egg.

Location.—Liver.

Life history.—The life history is simple and direct; that is, it does not involve any intermediate host. The eggs, as encountered in the liver of recently dead rats, are nonsegmented or in the very early stage of segmentation, and are not infectious.

Their development to the infectious embryonated stage is quite slow, taking about five to six months according to Bancroft and to Railliet, and only twenty-three days according to Momma (1930). If mature eggs are ingested by a proper host, hatching takes place in the small intestine and the newly liberated larvæ, after penetrating through the intestinal wall, reach the liver by way of the circulatory system, according to Fülleborn (1924). According to Nishigori (1925) and Asada (1925), they pass through the intestinal wall into the abdominal cavity, from which they make their way into the liver through the surface of this organ. In any case, the larvæ, after reaching the liver, stay there to complete their development. Larvæ may sometimes be carried to the lungs and other organs, in which case they do not become mature and sooner or later die.

In connection with this mode of development it is not yet clear how the eggs are discharged from the body and how they are transmitted from one host to another. According to Railliet (1892) and others who state that they have seen the eggs in the fæces, it is presumed that they escape through the intestinal tract from the liver through the bile duct. On the other hand, according to Bancroft (1893), Weidman (1925), and others who have failed to detect their presence in the fæces of infested animals, the belief is that the transmission of the eggs probably depends upon the cannibalistic habit of the host animals. This, however, could hardly be considered in the case of the human infestation recorded above. Even with rats direct infestation through cannibalism is possible only if a rat will devour another rat (infested) that has been dead for several months and in which the eggs have had time to develop into the infective stage. Indirectly, however, cannibalism may play a distinct rôle in the spread and propagation of the parasite if it could be shown that the immature eggs, as found in the liver, will still continue their development after passing through the digestive tract of a rat. In this connection the recent observations of Momma (1930) and Shorb (1931) are interesting. These authors cultured eggs derived from the fæces of flies and cats that had been fed on infested rat livers and found that they developed normally to the infective stage. It may, therefore, be deduced that the eggs of *Hepaticola hepatica* are disseminated through the natural decomposition and disintegration of the dead bodies of infested animals and through the capture and ingestion of infested rats and mice by their own

kind, or by cats, and other rat-preying animals. According to Momma, flies may play a rôle in the dispersal of the ova since they are often seen in large numbers around the decomposing bodies of dead rats.

Prevention.—Avoid rats and mice in houses; the dead bodies of these animals should not be allowed to decompose in the open, but should be buried deeply in the ground or burned; protect foods from rodents and from flies.

References.— 2, 3, 12, 14, 15, 19, 28, 29, 32, 45, 51, 57, 63.

Superfamily STRONGYLOIDEA Weinland, 1858; Hall, 1916

Family TRICHOSTRONGYLIDÆ Leiper, 1912

Subfamily HELIGMOSOMINÆ Travassos, 1914

Genus NIPPOSTRONGYLUS Lane, 1923

NIPPOSTRONGYLUS MURIS (Yokogawa, 1920) Lane, 1923. Fig. 12.

Synonym: *Heligmosomum muris* Yokogawa, 1920.

Description.—Body small, filiform, coiled, blood red in color when fresh. Cervical alæ absent, but cuticle inflated in head region (fig. 12, *a*); length of cuticular expansion 0.058 to 0.063 millimeter. Cuticle with ten longitudinal ridges originating behind inflated area; transverse striation of cuticle evident on these ridges. Mouth simple, leading into small buccal cavity. Œsophagus 0.30 to 0.40 millimeter long. Nerve ring 0.20 to 0.23 millimeter from anterior end. Excretory pore a short distance in front of nerve ring. Cervical papillæ lacking.

Male 3.2 to 3.5 millimeters long by 0.08 millimeter in maximum thickness at middle of body. Bursa well developed, with conspicuous asymmetrical lateral lobes and rays and small dorsal lobe (fig. 12, *b*). Right lobe larger, at least longer, than left lobe, its supporting rays differing from those of opposite side: ventroventral ray small, slender, widely separated from lateroventral which is also thin but longer; externolateral and mediolateral thick and close together except at their tips; posterolateral small and delicate; externodorsal on both sides thin and slender, arising at slightly higher level from common trunk with dorsal ray. In the left lateral bursal lobe, the ventroventral, lateroventral, externolateral and mediolateral rays are almost similar in form, being long and thin; posterolateral thicker and curved dorsally, ending in a conical tip. Dorsal ray bifurcate at its tip, each limb ending in two or three digitations. Spicules yellowish in color, equal, filiform, 0.44 to

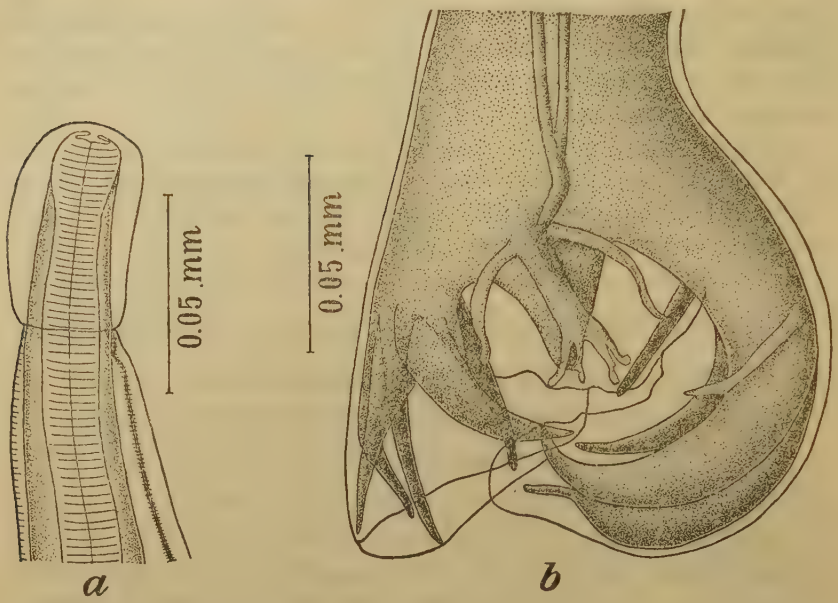

FIG. 12. *Nippostrongylus muris*. *a*, Anterior end, lateral view; *b*, bursa, dorsal view.

0.50 millimeter in length by 6 to 7 microns in maximum width at their proximal ends, with sickle-shaped extremities that are usually united together. Gubernaculum colorless, 44 to 46 microns long.

Female 4.0 to 4.6 millimeters in length by 0.135 millimeter in maximum thickness at middle of body. Posterior end behind vulva reduced abruptly in diameter ending in a short, curved, conical tail; in contracted specimens this region of the body may appear swollen and bell-shaped due to the invagination of the cuticle which carries with it the anus and the vulva. Anus about 32 microns from tip of tail. Vulva in front of anus, about 80 microns from tip of tail; vagina muscular, separated from uterus by ovejector; uterus short, modified anteriorly into receptaculum seminis; ovary long, with short anterior loop. Eggs few in number, thin shelled, segmented at deposition, 58 to 60 by 30 to 32 microns in size.

Location.—Small intestine.

Life history.—The life history of this nematode has been worked out by Yokogawa (1922). When passed out in the fæces of the host, the eggs are in various stages of segmentation. Under favorable conditions their development is continued outside and hatching takes place after about twenty to twenty-four hours.

The newly hatched larvæ attain the infective stage after about five days. The infection of new hosts is accomplished, as in the case of hookworms, by the larvæ entering the body either through the skin or by way of the mouth, the former method having been shown to be more effective. After passing through the lungs the larvæ settle down in the intestine where they reach sexual maturity in seven to ten days after infestation.

References.—26, 60, 62, 63.

Superfamily OXYUROIDEA Railliet, 1916

Family OXYURIDÆ Cobbold, 1864

Subfamily SYPHACIINÆ Railliet, 1916

Genus SYPHACIA Seurat, 1916

SYPHACIA OBVELATA (Rudolphi, 1802) Seurat, 1916. Fig. 13.

This parasite is listed by Shipley (1908) and by Stiles and Hassall (1910) among the nematodes reported from *Mus norvegicus*. As already stated, it was not encountered in the present survey, but attention is called to it in view of its recorded occurrence in the Philippine Islands by Riley (1919) who identified it from specimens found in a sample of human stools obtained from an American Bohemian child residing in Zamboanga, Mindanao, and forwarded to him by Dr. Albert F. Coutant. The following description is mostly adopted from Hall (1916).

Description.—Body elongate, fusiform. Cuticle transversely striate, not dilated in head region. Two small cervical alæ present (fig. 13, *a*). Mouth bounded by three lips, each bearing a median papilla on its outer face; mouth cavity simple. Œsophagus club-shaped with a posterior bulb containing a valvular apparatus and separated from the rest by a constriction. Excretory pore a little posterior of level of œsophageal bulb.

Male (fig. 13, *b*) 1.3 millimeters long by 115 microns thick, with two or three cuticular "mamelons" on ventral surface. Posterior extremity coiled in a spiral and ending in a long pointed tail. Narrow caudal alæ present, limited to first part of tail, supported by two pairs of preanal and one pair of postanal pedunculated papillæ (fig. 13, *c*). Spicule simple, slightly curved, 85 microns long by 7 microns thick at base; gubernaculum shaped like a ploughshare, 37 microns long, directed transversely posterior of spicule. Cloacal aperture 210 microns from tip of tail; posterior lip of aperture with a small chitinous hook that may be of use in copulation.

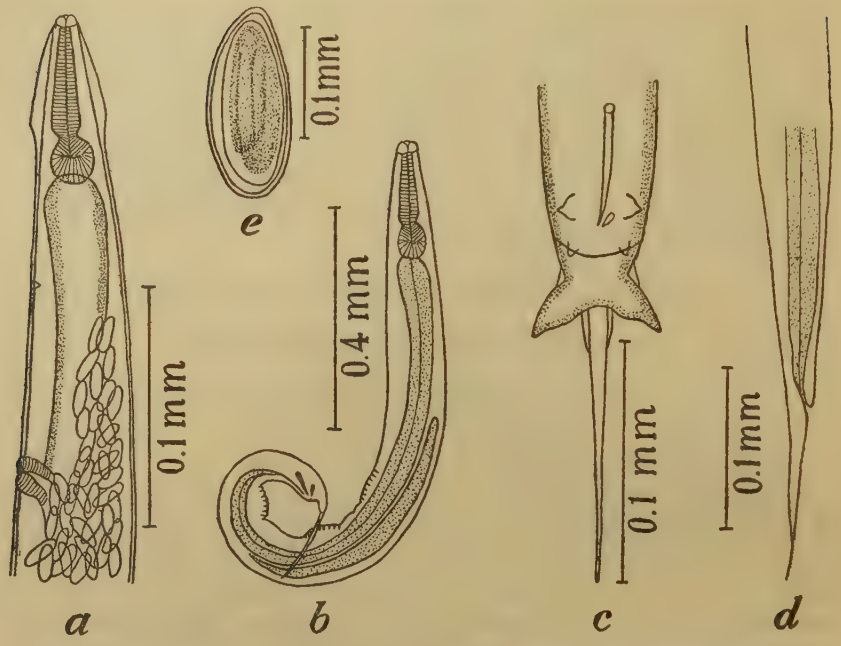

FIG. 13. *Syphacia obvelata*. *a*, Anterior end of female, lateral view; *b*, male, lateral view; *c*, posterior end of male, ventral view; *d*, posterior end of female, lateral view; *e*, egg. (All from Yorke and Maplestone, 1926.)

Female 3.5 to 5.7 millimeters long by 115 to 215 microns thick. Body terminates in a long, narrow tip posteriorly (fig. 13, *d*.) Œsophagus, exclusive of bulb, 255 to 330 microns long by 50 to 70 microns thick; œsophageal bulb 85 to 100 by 75 to 110 microns in size. Nerve ring 100 to 130 microns from anterior end. Anus 515 to 705 microns from tip of tail. Vulva prominent, behind excretory pore, situated on conical cuticular prominence 540 to 740 microns posterior of head. Vagina extends posteriorly from vulva, elongate, about 170 microns long. Uterine branches do not extend posterior of anus. Eggs 110 to 142 by 30 to 40 microns in size, nonembryonated at time of oviposition (fig. 13, *e*).

Location.—Cæcum and large intestine.

Life history.—Unknown. Probably similar to that of closely related nematodes, such as, *Enterobius vermicularis*, the human pin worm, the life history of which is simple and direct.

Prevention.—Taking for granted that the life history of this parasite is simple and direct, the preventive measures that suggest themselves are the observance of personal cleanliness, es-

pecially after defecation, the proper disposal of the stools of infected individuals, the destruction of rats and mice, and the protection of foods from the droppings of these animals.

References.—14, 19, 34, 42, 44, 50, 51, 63.

Family HETERAKIDÆ Railliet and Henry, 1914

Subfamily HETERAKINÆ Railliet and Henry, 1912

Genus HETERAKIS Dujardin, 1845

HETERAKIS SPUMOSA Schneider, 1866. Fig. 14.

Synonym: *Ganguleterakis gangula* Lane, 1914.

Description.—Body small, tapering slightly towards the anterior end. Cuticle with fine longitudinal and transverse striations and with lateral flanges in œsophageal region (fig. 14, *a*). Head 70 to 75 microns in diameter. Mouth with three subequal lips, each lip carrying two lateral papillæ. Œsophagus 0.75 to 0.83 millimeter long, subcylindrical, terminating in a well-developed bulb; latter 0.15 to 0.17 millimeter in diameter, provided with a valvular apparatus. Distance from anterior end to nerve ring 0.22 to 0.24 millimeter; to excretory pore 0.29 to 0.31 millimeter; to cervical papillæ 0.30 to 0.34 millimeter.

Male 6.0 to 7.4 millimeters in length by 0.25 millimeter in maximum thickness. Tail short and sharply pointed. Caudal alæ well developed, provided with ten pairs of papillæ grouped as follows (fig. 14, *c*): an anterior group of two pairs of ventral papillæ lateral to genital sucker, a middle group of two pairs of ventral and three pairs of lateral papillæ in the cloacal region, and a posterior group of three pairs of lateral papillæ near tip of tail. The anterior group of papillæ are all slender; in the middle group the ventral pairs are short and knobby, while the lateral pairs vary in size and appearance, the first pair being the largest, the second pair thick but short, and the last pair longer but slender; the posterior group of papillæ are relatively small, the middle pair being the largest among them. Genital sucker slightly oval transversely, pedunculate, with a strong chitinous rim interrupted posteriorly by a papilliform projection; average size 0.076 by 0.087 millimeter and about 0.15 millimeter from cloacal opening. Spicules subequal, tapering distally, 0.280 to 0.315 millimeter in length. Gubernaculum absent. Cloacal opening 0.29 to 0.32 millimeter from tip of tail.

Female 7.8 to 9.5 millimeters in length by 0.30 to 0.32 millimeter in maximum thickness. Tail long and acutely pointed (fig. 14, *b*). Anus 0.58 to 0.64 millimeter from tip of tail.

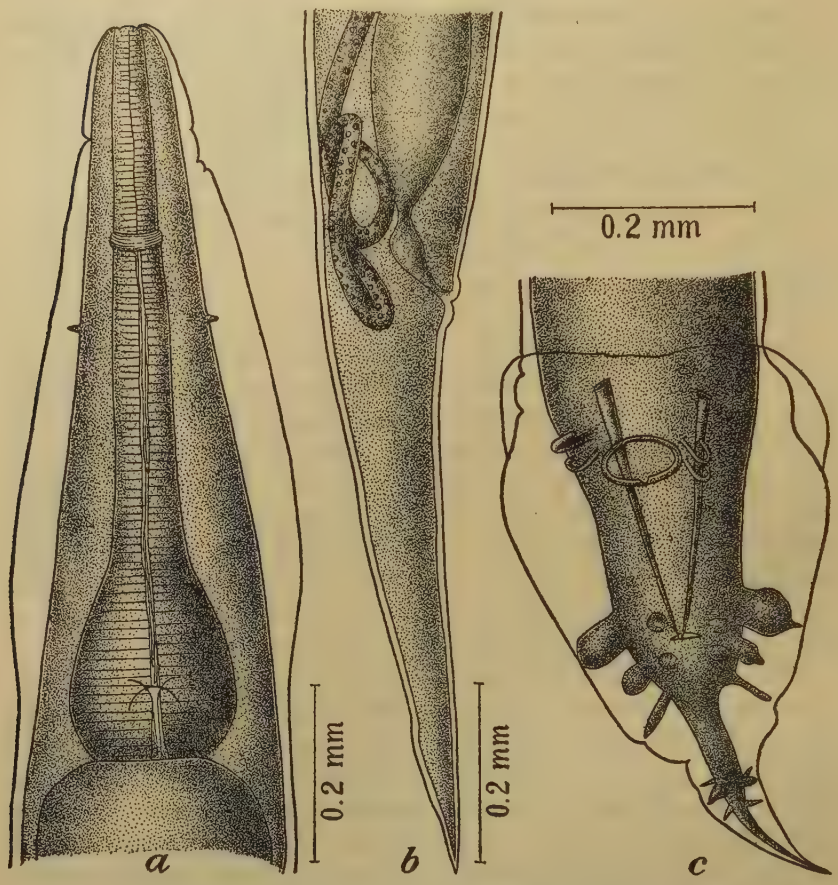

FIG. 14. *Heterakis spumosa*. *a*, Anterior end of female, ventral view; *b*, posterior end of female, lateral view; *c*, posterior end of male, ventral view.

Vulva slightly posterior of middle of body length. Vagina muscular, is at first directed anteriorly, then bends posteriorly and divides into anterior and posterior uterine branches. Ovaries in numerous transverse coils in anterior and posterior end of body. Eggs oval, thick shelled, in the early stage of segmentation at deposition, 56 to 65 by 38 to 40 microns in size; shell about 4 microns in thickness.

Location.—Large intestine (cæcum).

Life history.—Not worked out, but possibly similar to that of *Heterakis gallinæ* of poultry, in which case it is simple and direct. Briefly the life history of *H. gallinæ* is as follows: The eggs are passed outside with the fæces of the host. Under

favorable conditions of temperature and moisture, the egg becomes embryonated; that is, a larva is developed inside each egg, and is then infective. If the egg is swallowed by a proper host, hatching takes place in the intestine and the liberated larva soon settles down in the cæcum to grow into an adult. The larvæ do not wander into the lungs as is the case with the larvæ of *Ascaris*.

References.—19, 63.

Superfamily SPIRUROIDEA Railliet and Henry, 1915

Family SPIRURIDÆ Oerley, 1885

Subfamily SPIROXYINÆ Baylis and Lane, 1920

Genus PROTOSPIRURA Seurat, 1914

PROTOSPIRURA MURICOLA Gedoelst, 1916. Fig. 15.

This is possibly the small *Ascaris* which Schöbl (1913) has observed as being not uncommon in the intestine of Philippine rats. Its normal habitat is the stomach, but after the death of the host it often migrates into the small intestine.

The specimens at hand differ greatly among themselves in size, some females in particular being almost twice as large as other females. In the beginning it was thought that the collection represented two species, but it was later revealed that outside of size there were no other morphological differences.

Description.—Body relatively large, regularly attenuated anteriorly. Cuticle transversely striated. Mouth (fig. 15, *b*) with two large lateral lips, each divided into three lobes, of which the middle is larger; each lobe bears two cuticular projections, but no teeth. There are five pairs of head papillæ; namely, one large pair of subventral, a smaller pair of submedian, the dorsal homologues of these, and a minute pair of lateral papillæ. Pharynx (fig. 15, *a*) prominent, laterally compressed, with thick chitinous wall. Œsophagus very elongate, subcylindrical, slightly constricted in region of nerve ring, separated from intestine by valvular apparatus. Cervical papillæ not prominent, in front of nerve ring. Excretory pore ventral, behind nerve ring.

Male 25 to 30 millimeters in length by 0.80 millimeter in maximum thickness at middle of body. Average length of pharynx 0.09 millimeter; of œsophagus 6.20 millimeters. Distance from anterior end to cervical papillæ 0.32 to 0.35 millimeter; to nerve ring 0.38 to 0.41 millimeter; to excretory pore

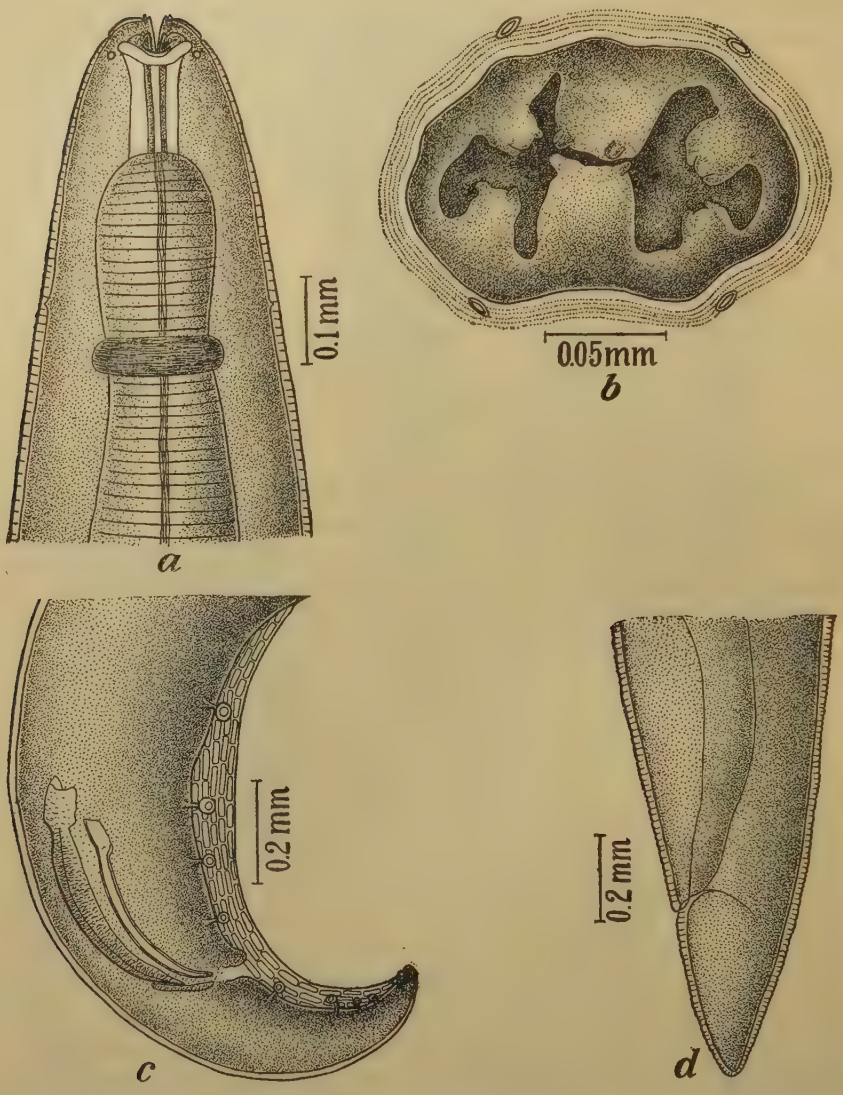

FIG. 15. *Protospirura muricola*. *a*, Anterior end of female, ventral view; *b*, mouth, anterior view; *c*, posterior end of male, lateral view; *d*, posterior end of female, lateral view.

0.43 to 0.45 millimeter. Caudal end of body conical, spiral, carrying moderately developed symmetrical bursa (fig. 15, *c*). Latter with cuticular oblong markings and usually supported by nine pairs of pedunculated papillæ, of which four pairs are larger and preanal in position and five pairs smaller and postanal. Sometimes an extra pair of minute papillæ is present near

tip of tail. Both spicules bent, with enlarged proximal extremities and pointed distal ends, but unequal in size and structure; left spicule spongy, larger, 0.40 to 0.43 millimeter in length by 0.058 to 0.060 millimeter in maximum thickness at proximal end; right spicule hollow, 0.36 to 0.39 by 0.041 to 0.042 millimeter in size. Gubernaculum small, slender, 0.10 millimeter long. Average distance from tip of tail to cloacal opening 0.42 millimeter.

Female 35 to 52 millimeters in length by 1.20 millimeters in maximum thickness at middle of body. Pharynx 0.10 to 0.13 millimeter, œsophagus 6.40 to 7.90 millimeters long. Distance from anterior end to cervical papillæ 0.33 to 0.40 millimeter; to nerve ring 0.38 to 0.47 millimeter; to excretory pore 0.48 to 0.70 millimeter. Caudal end of body bluntly conical (fig. 15, *d*). Anus 0.40 to 0.42 millimeter from posterior end. Vulva a short distance in front of middle of body length. Uteri divergent, anterior uterus reaching anteriorly to almost as far as œsophago-intestinal junction and the posterior uterus extending to a short distance in front of anus. Eggs oval, embryonated at deposition, thick shelled, 50 to 57 by 38 to 44 microns in size.

Location.—Stomach.

Life history.—Probably similar to that of *Protospirura muris* (Gmelin, 1790) and of *P. columbiana* Cram, 1926, in which intermediate hosts are involved. Cram gives the life history of *P. columbiana* as follows: If the embryonated eggs of the parasite are fed to cockroaches (*Phyllodromia germanica*), the liberated larvæ find their way to the body cavity, where they begin to encyst in about a month after feeding. The cysts, however, are not infective at this time. After forty-one days they appear to have reached that stage and if fed to rats the encysted larvæ are capable of pursuing further development in the stomach of the latter. They become fully grown and mature one hundred fifteen days after the feeding of the final host.

References.—6, 9, 19, 40, 63.

Subfamily GONGYLONEMINÆ Hall, 1916

Genus GONGYLONEMA Molin, 1857

GONGYLONEMA NEOPLASTICUM (Fibiger and Ditlevsen, 1914) Ransom and Hall, 1916
Figs. 16 and 17.

Synonym: *Spiroptera neoplastica* Fibiger and Ditlevsen, 1914.

Two species of the genus *Gongylonema* have been reported from rats; namely, *G. neoplasticum* and *G. orientale* Yokogawa,

1925. They are said to differ from each other in the following respects: Morphologically, in total size, length of œsophagus, spicules and vas deferens, structure of the spermatozoa, size of the eggs, etc; biologically, in the time necessary for the sexes to reach maturity in experimental infestations. In view, however, of the observations of Seurat (1916) and Baylis (1925) on the degree of morphological variations exhibited by members of the genus, it is not unlikely that the two rodent parasites are identical. Baylis even goes further in suspecting that *G. neoplasticum* is similar to *G. pulchrum* of the pig, between which the differences are much greater and, therefore, more apparent. This, however, could hardly be the case, for, if it were so, it would be difficult to explain why a parasite that is so common in rats has not yet been reported in Philippine domesticated animals. The writer has looked for *G. pulchrum* with uniformly negative results in swine, sheep, goats, and cattle.

This parasite has received considerable attention due to the report of Fibiger and Ditlevsen (1914) that it is instrumental in the production of carcinomatous growths in rats. In the present survey this possible rôle of the parasite was kept constantly in mind, but of the rats found harboring it not one presented a gastric tumor. The condition must be rare in Philippine rats, for Schöbl (1913), who examined tens of thousands of these animals in connection with plague, records only one case of tumor located on the large curvature of the stomach. No determination was made as to the possible origin of the new growth.

Description.—Body long, slender, threadlike, terminating in a blunt cone anteriorly. Cuticle transversely striate; bears in cephalic and œsophageal regions more or less globular, egg-shaped or sausage-shaped cuticular plaques or bosses, of variable size and arranged irregularly in longitudinal rows on body surface (fig. 16). Lateral bands present, extending on both sides throughout body length except at most anterior and most posterior regions. Cervical papillæ inconspicuous, in front of nerve ring. Excretory pore ventral, behind nerve ring. Mouth small, surrounded by four very inconspicuous lips; buccal rim 0.02 to 0.03 millimeter in diameter. Œsophagus very long, in two parts—anterior muscular and posterior glandular— separated from intestine by constriction and intestinal valves.

Male 11.0 to 12.0 millimeters in length by 0.20 millimeter in maximum thickness at middle of body. Pharynx 0.05 millime-

ter long. Anterior portion of œsophagus 0.4 millimeter long, posterior portion 2.4 millimeters; total length of œsophagus, therefore, about one-fourth of total body length. Distance from anterior end of worm to cervical papillæ 0.13 millimeter, to nerve ring 0.22 millimeter, to excretory pore 0.34 millimeter. Tail (fig. 17, *a*) slightly twisted on its long axis, provided with asymmetrical alæ, the left wing being usually longer than the right. Eight pairs of pedunculated caudal papillæ present, of which four pairs are slightly larger and preanal and four pairs postanal; last postanal pair very minute; at least a pair of sessile papillæ often present near tip of tail. Spicules very dissimilar; short one usually on the right, sword-shaped, 0.125 by 0.015 millimeter in size; left spicule filiform, 0.740 millimeter long, of nearly uniform thickness (0.006 millimeter) throughout except at proximal end, where it is dilated. Gubernaculum asymmetrical, 0.065 millimeter long.

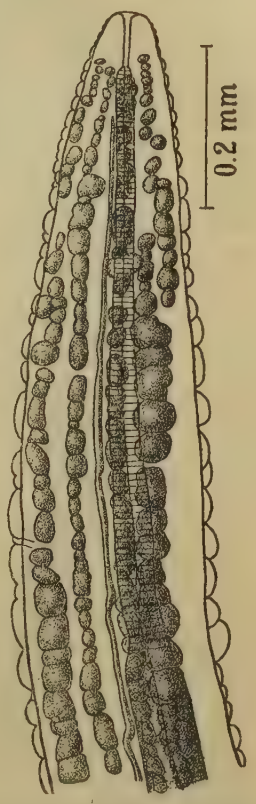

FIG. 16. *Gongylonema neoplasticum*, anterior end, lateral view.

Female 35.0 to 70.0 millimeters in length by 0.20 to 0.35 millimeter in thickness at middle of body. Posterior end behind anus formed into a pointed, ventrally curved tail (fig. 17, *b*). Pharynx 0.058 to 0.072 millimeter long. Anterior portion of œsophagus 0.46 to 0.78 millimeter long, posterior portion 4.0 to 7.6 millimeters; total length of œsophagus 4.5 to 8.4 millimeters or about one-eighth to one-ninth of total body length. Distance from anterior end of worm to cervical papillæ 0.13 to 0.16 millimeter, to nerve ring 0.23 to 0.25 millimeter, to excretory pore 0.60 to 0.66 millimeter. Vulva not prominent, behind middle of body. Distance from tip of tail to vulva 2.6 to 5.9 millimeters, and to anus 0.17 to 0.21 millimeter. Vagina short, directed anteriorly from vulva and followed by long ovejector. Uteri divergent; anterior uterus becomes receptaculum seminis near posterior end of œsophagus, the posterior uterus being similarly modified behind level of vulva. Ovaries much coiled. Eggs oval, embryonated at deposition, 54

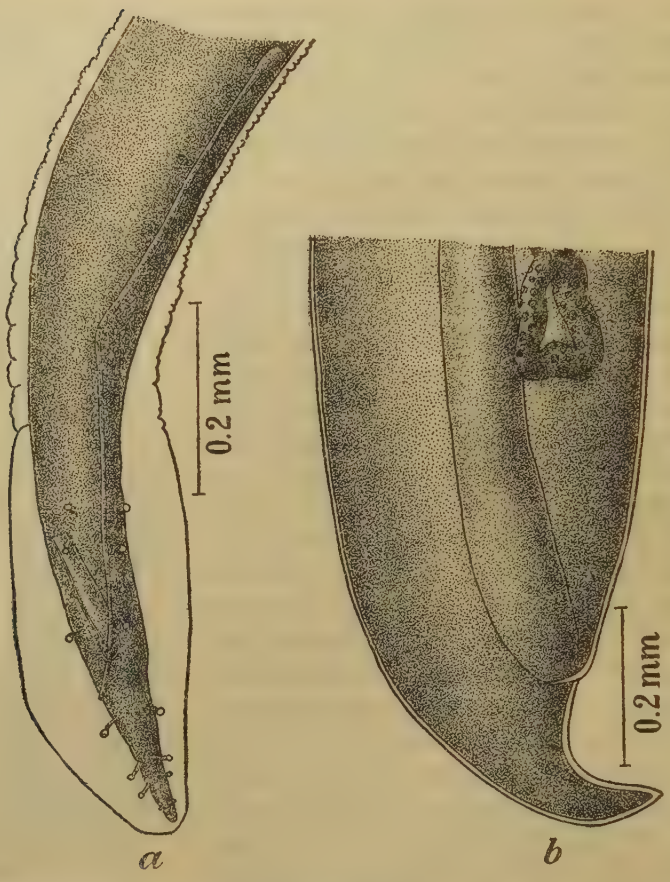

FIG. 17. *Gongylonema neoplasticum.* *a*, Posterior end of male, ventral view; *b*, posterior end of female, lateral view.

to 56 by 34 to 36 microns in size, with smooth shell about 3 microns in thickness.

Location.—Squamous-celled anterior portion of digestive tract, usually beneath gastric mucosa.

Life history.—The development of this parasite requires an intermediate host, which is invariably an insect. Cockroaches, such as, *Blatta orientalis, Phyllodromia germanica,* and *Periplaneta americana;* dung beetles, such as, *Ateuchus, Aphodius,* and other genera of the family Scarabæidæ; cellar beetles and mealworm beetles of the family Tenebrionidæ are all possible intermediate hosts. Hall (1916) describes the life history as follows: The eggs of the worm are passed out of the body in desquamations of the epithelium of the digestive tract with the

fæces. If ingested by any one of the above insects, they hatch in the intestine, and the liberated embryos, which measure 250 by 13 microns, follow a certain route and are finally found encapsulated in the musculature of the prothorax and legs of the intermediary host. At this stage the larvæ are 0.792 to 1.215 millimeters long and are coiled in spirals within their individual cysts. They are rather slender and possess a conical tail that often terminates in two or three papillalike projections of variable size. Occasionally a wing-shaped prominence with fringed or serrate edges is present. Anteriorly the larvæ are very similar in appearance to the mature worms, except that the pharynx is relatively longer than in the adult and the œsophagus is nearly as long as the intestine. In the beginning the growth of the encapsulated larvæ is faster towards the anterior end, but later the rate of growth is reversed. The nerve ring and excretory pore are distinct, the latter located halfway between the former and the union of the two portions of the œsophagus. Near the region where the vulva will later develop in the female, the anlage of the reproductive system appears in the form of an oval body consisting of a number of cells or a syncytium with several nuclei.

If an insect harboring these encysted larvæ is ingested by a proper vertebrate host, such as a rat, the latter are liberated from their capsules due no doubt to the action of the gastric juice, and on the following day they will be found to have penetrated into the mucous membrane of the stomach and sometimes also into that of the œsophagus and tongue. During the first ten days growth is rather slow, the larvæ only doubling their original length. They molt at about this time and their tails become simple like those of the adult worms. Then they grow more rapidly, and after two months the females begin to deposit eggs.

References.—4, 5, 19, 40, 43, 63.

Family RICTULARIIDÆ Railliet, 1916

Subfamily RICTULARIINÆ Hall, 1913

Genus RICTULARIA Froelich, 1802

RICTULARIA WHARTONI sp. nov. Fig. 18.

This nematode is named in honor of the late Mr. Lawrence D. Wharton, one of the early pioneers in the field of parasitology in the Philippine Islands.

Description.—Male unknown.

Female 25 to 33 millimeters in length by 0.65 to 0.90 millimeter in thickness across middle of body. Cuticle transversely striated, often swollen anteriorly forming a pair of ventrolateral cuticular expansions 0.40 to 0.90 millimeter long (fig. 18, *a*). Anterior end bent ventrally in preserved specimens, the rest of body length turned towards opposite direction or rolled into a semicircle; posterior end conical, ending in a short fine point (fig. 18, *c*). Head 0.145 to 0.195 millimeter in thickness across base of buccal capsule, provided with two ventral papillæ. Buccal capsule well developed, 0.05 to 0.07 by 0.06 to 0.08 millimeter in size, with its aperture surrounded by a series of denticles (corona radiata) and its base armed with three conical teeth possessing serrated borders (fig. 18, *b*). Œsophagus 3.5 to 4.6 millimeters long. Nerve ring 0.30 to 0.35 millimeter from anterior end. Cervical papillæ not very conspicuous, 0.70 to 0.74 millimeter from anterior end. There are 42 to 43 pairs of "combs" extending from the head to the level of the vulva and measuring 0.045 by 0.015 to 0.200 by 0.145 millimeter; first pair of "combs" almost ridgelike, the rest bigger, more distinct and gradually becoming more spinelike (fig. 18, *a*). Behind the vulvar level there are 47 to 50 pairs of spines 0.05 to 0.16 millimeter long, the first three or five pairs being really of a transitional type and the most posterior pair shorter; last pair of spines immediately behind level of anal opening. Vulva moderately prominent, usually in front (0.3 millimeter) of level of posterior end of œsophagus, occasionally directly opposite or even slightly behind this level. Vagina directed posteriorly from vulva. Uteri convergent. Eggs with smooth fairly thick shell, embryonated at time of deposition, measuring 44.2 to 47.5 by 34 microns. Anus 0.215 to 0.270 millimeter from tip of tail.

Specific diagnosis.—Rictularia: Male unknown. Female 25 to 33 millimeters in length by 0.65 to 0.90 millimeter in maximum thickness; with a pair of ventrolateral cuticular dilatations in cervical region. Base of buccal capsule armed with three conical teeth possessing serrated borders. Œsophagus 3.5 to 4.6 millimeters long; distance from anterior end to nerve ring 0.30 to 0.35 millimeter; to cervical papillæ 0.70 to 0.74 millimeter. Forty-two to forty-three pairs of "combs" from head to level of vulva and forty-seven to fifty pairs of spines from immediately behind vulvar level to posterior end of body. Vulva usually in front of posterior end of œsophagus. Anus 0.215 to 0.270 millimeter from tip of tail. Eggs 44.2 to 47.5 by 34.0 microns in size.

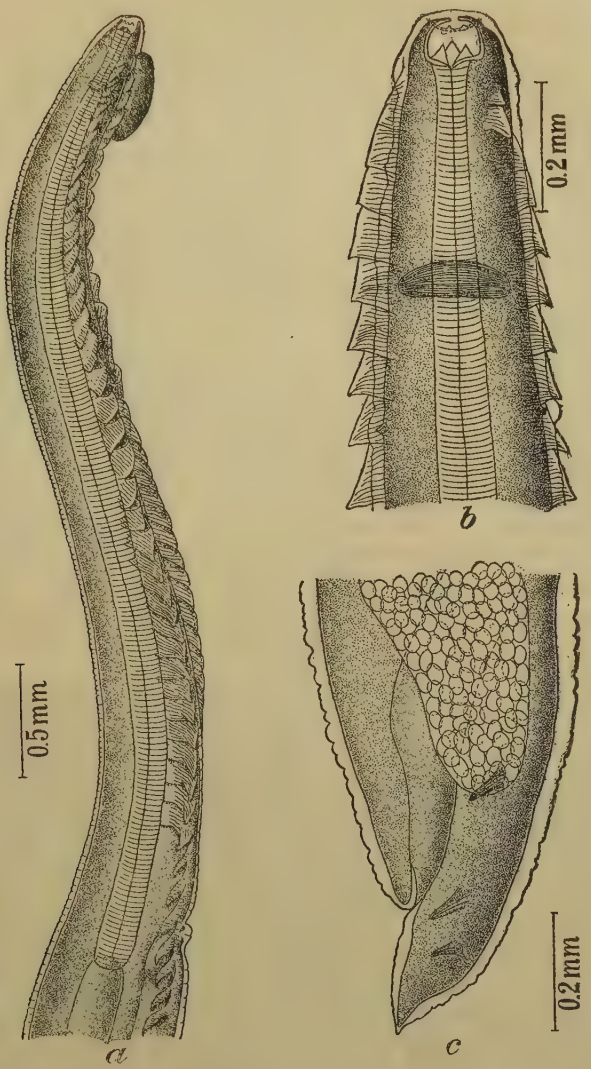

FIG. 18. *Rictularia whartoni* sp. nov. *a*, Anterior end of female, lateral view; *b*, anterior end of female, ventral view; *c*, posterior end of female, lateral view.

Location.—Stomach and small intestine.

Locality.—Manila, P. I.

Type specimens.—Philippine Bureau of Science parasitological collection, No. 10.

Life history.—Unknown.

Reference.—6, 19, 63.

Class ACANTHOCEPHALA Rudolphi, 1808

Order ECHINORHYNCHATA Faust, 1929

Family MONILIFORMIDÆ Van Cleave, 1924

Genus MONILIFORMIS Travassos, 1915

MONILIFORMIS MONILIFORMIS (Bremser, 1811) Travassos, 1915. Fig. 19.

Synonyms: *Echinorhynchus moniliformis* Bremser, 1811; *Gigantorhynchus moniliformis* (Bremser, 1811) Railliet, 1893; *Hormorhynchus moniliformis* (Bremser, 1811) Ward, 1917; *Echinorhynchus cestodiformis* Linstow, 1904.

This is appropriately known in ordinary language as the beaded thorn-headed worm. In the adult stage it is a common parasite of rats and other rodents and occasionally of dog and man. Calandruccio (1888), who infected himself experimentally by ingesting several infective larvæ, was able to demonstrate that the presence of the parasite in man in large numbers may produce diarrhœa and severe gastrointestinal pain accompanied by exhaustion, somnolence, and ringing of the ears. The expulsion of the worms with male fern caused the symptoms to disappear two days after the treatment.

Description.—Body whitish or creamy-white in color, attenuated at both extremities, divided superficially except at extreme anterior and posterior ends by annular grooves into a series of beadlike pseudo-segments that give the worm a moniliform appearance. Size very variable in both sexes, the smallest specimens usually immature. Proboscis (fig. 19, *a*) cylindrical, protrusible, relatively short, with broadly rounded distal end; 0.425 to 0.670 by 0.15 to 0.21 millimeter in size, armed with 12 to 16 longitudinal rows of recurved hooks, each row composed of 7 to 12 hooks; hooks 24 to 30 microns long, each with a single posteriorly directed root process (fig. 19, *b*). Proboscis sheath large, 0.5 to 1.3 by 0.22 to 0.42 millimeters in size, its wall composed of two muscular layers, of which the outer is made up of diagonally wound fibers. Lemnisci filiform, 2.4 to 10.0 millimeters long, with few large nuclei.

Male 5.5 to 86.0 millimeters in length by 1.0 to 1.5 millimeters in maximum breadth at middle of body; posterior end expanded into small bell-shaped bursa copulatrix, which, however, is usually retracted within the body, being forced out only during the copulatory act or as the result of the contraction of the wall during the preservation of the specimen. Reproductive organs

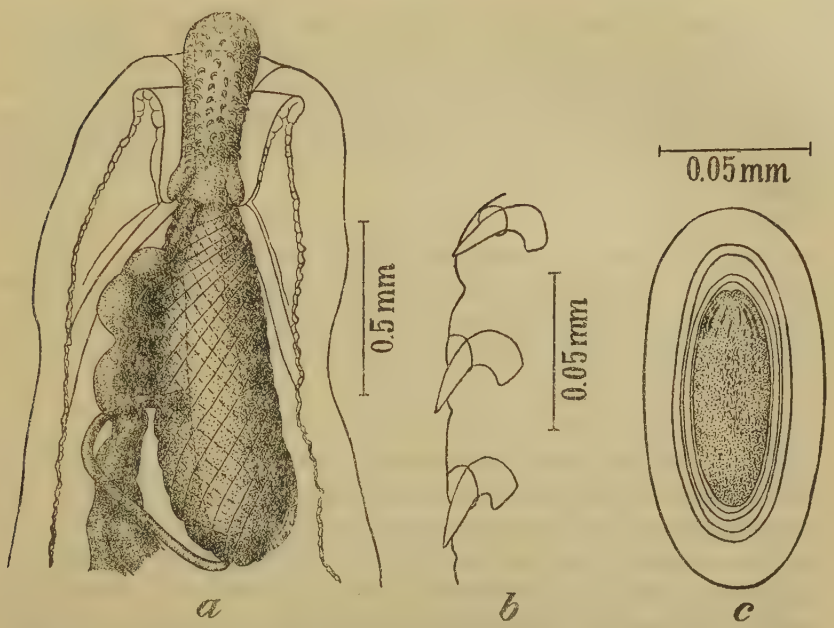

FIG. 19. *Moniliformis moniliformis*. *a*, Anterior end, lateral view; *b*, hooks; *c*, egg.

at posterior portion of body cavity. Testes, of which there are two, are oval, elongated, one immediately behind the other, 0.2 to 4.0 (usually 2.0) by 0.12 to 0.96 millimeters in size. Prostatic glands eight in number, roundish to oval in shape, compressed and crowded together behind testes, the entire mass measuring in mature worms 0.45 to 3.60 by 0.25 to 1.10 millimeters.

Female 7 to 270 by 1.5 millimeters in size. Ovary present only in larval stage, produces large numbers of ova which later are found free in the body cavity of the adult worm. Eggs ellipsoidal, 109 to 137 by 40 to 63 microns in size, and provided with three envelopes; in fully mature eggs outer shell slightly wrinkled and the inclosed embryo brown or dark-colored, striated and covered with minute spines (fig. 19, *c*).

Location.—Small intestine.

Life history.—Indirect, the intermediate hosts being species of beetles (*Blaps mucronata*), cockroaches (*Periplaneta americana*), and possibly other insects. If ingested by these insects the eggs develop into oval larvæ in their abdominal cavities. Each larva is inclosed in a very delicate cyst, which, according to Southwell (1922) is easily lost. The larva on being swallowed by a suitable mammalian host together with the insect har-

boring it escapes from its cyst (if this has not already been lost) and develops directly into an adult worm. The mode of infection in man is somewhat obscure; it may result from the accidental ingestion of either of the infected intermediate host or food polluted by cysts from disintegrated cockroaches and beetles.

Prevention.—Consists in the destruction of rats and mice that play the rôle of reservoirs and of cockroaches and beetles that act as intermediate hosts of the parasite. Foods should be protected from these insects.

References.—14, 46, 47, 51, 53, 54, 56.

SUMMARY

Besides the rôle that they play as carriers and reservoirs of bubonic plague and other bacterial as well as spirochætal infections, rats often harbor parasitic worms, some of which are also a menace to human health. In view of this and because of the fact that the helminthic fauna of rats has never been studied extensively in the Philippine Islands, it seemed desirable to undertake a systematic examination of these animals for the purpose of finding out if they are infested with parasites that are transmissible to man.

The examination of nine hundred fifty rats (*Mus norvegicus*) resulted in the identification of the following sixteen species of helminths: Trematodes: *Euparyphium ilocanum, E. guerreroi,* and *E. murinum* sp. nov.; cestodes: *Tænia tæniaformis* (larval form), *Raillietina garrisoni* sp. nov., *Hymenolepis diminuta,* and *H. nana;* nematodes: *Gongylonema neoplasticum, Hepaticola hepatica, Heterakis spumosa, Nippostrongylus muris, Protospirura muricola, Rictularia whartoni* sp. nov., *Strongyloides ratti* and *Trichosomoides crassicauda; Acanthocephala: Moniliformis moniliformis.*

The following parasites of rats have been reported from human beings: *Euparyphium ilocanum, Hymenolepis diminuta, H. nana, Syphacia obvelata, Hepaticola hepatica,* and *Moniliformis moniliformis.* The first four species mentioned in this paragraph have been reported to occur in man in the Philippine Islands.

It is also believed that *Raillietina garrisoni* should be included among the parasites of the rat that are transmissible to man because of its common occurrence and its close morphological

resemblance to the human tapeworm described by Garrison in 1911 from the Philippines as *Davainea madagascariensis.*

The morphology and the life history, if known, of each of the different parasites are given and, in the case of the forms that are transmissible to man, methods of avoiding infestation are discussed.

ADDENDUM

After the manuscript of the above paper was submitted for publication, I found in the literature a description by Hoeppli [2] of a new nematode, *Rictularia tani,* from the brown rat in Amoy, China, with which *Rictularia whartoni* Tubangui should be compared. The two forms resemble each other in several important characters, such as, in the number of their cuticular combs and spines, the length of the œsophagus, and the location of the nerve ring, vulva and anus. They differ in the presence of a pair of ventrolateral cuticular dilatations in *R. whartoni* and in the fact that the last pair of spines of *R. whartoni* is found behind the anus, that of *R. tani* occurring in front of that level. Because of these differences it is decided to maintain the Philippine *Rictularia* as a separate species.

Very recently there also came to hand a paper by Lopez-Neyra [3] that has an important bearing on the discussion of *Raillietina garrisoni.* I described this as a new species of rat tapeworm for, while recognizing its close alliance to *Raillietina celebensis* (Janicki) Meggitt and Subramanian, 1927, it differs from the latter in the number of its testes and uterine egg capsules and in the size of its cirrus pouch. I also gave reasons for suspecting its possible identity with Garrison's *Davainea madagascariensis* which, according to Joyeux and Baer, differs from the specimens described under the same name by other observers. Now, according to Lopez-Neyra, the following represent one and the same species of parasite that should be known as *Kotlania madagascariensis* (Davaine, 1869): the collections in the Parasitological Laboratory of the University of Paris denominated as Type No. 108 (Davaine), No. 109 (Davaine), No. 8 (Blanchard, Port-Louis) and No. 33 (Nossi-Bè, 1873); *Taenia madagascariensis* Leuckart, 1891; *Davainea madagascariensis* Garrison, 1911; *D. formosana* Akashi, 1916; *Raillietina*

[2] Centralbl. f. Bakteriol. u. Parasitenk. 1 Abt. Orig. 110 (1929) 75–78.

[3] Ann. Parasit. Hum. et Comp. 9 (1931) 162–184.

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celebensis (Janicki) Meggitt and Subramanian, 1927; *R. funebris* Meggitt and Subramanian, 1927; and possibly *R. fluxa* Meggitt and Subramanian 1927. If Lopez-Neyra's hypothesis is accepted, then *Raillietina garrisoni* will have to fall in line with the above synonymy.

REFERENCES

1. Ando, A., and Y. Ozaki. Sur quatre nouvelles espèces de trèmatodes du genre Echinostoma. (In Japanese.) Dobutsu Gaku Zasshi 35 (1923) 108–119. Reviewed by Dollfus (1925).
2. Asada, J. On the development of Hepaticola hepatica. (In Japanese.) Jap. Journ. Zool. 37 (1925). Cited by Momma (1930).
3. Bancroft, T. L. On the whipworm of the rat's liver. Journ. and Proc. Roy. Soc. New South Wales, Sydney 27 (1893) 86–90.
4. Baylis, H. A. On Gongylonema collected in Italy during October, 1924, with some observations on the genus. Journ. Trop. Med. and Hyg. 28 (1925) 71–76.
5. Baylis, H. A. On the species of Gongylonema (Nematoda) parasitic in ruminants. Journ. Comp. Pathol. and Therap. 38 (1925) 46–55.
6. Baylis, H. A. On a collection of nematodes from Nigerian mammals (chiefly rodents). Parasit. 20 (1928) 280–304.
7. Chandler, A. C. The species of Strongyloides (Nematoda). Parasit. 17 (1925) 426–433.
8. Chandler, A. C. The distribution of Hymenolepis infections in India with a discussion of its epidemiological significance. Indian Journ. Med. Res. 14 (1927) 973–994.
9. Cram, E. B. A new nematode from the rat and its life history. Proc. U. S. Nat. Mus. 68 (1926) 1–7.
10. Dietz, E. Die Echinostomiden der Vögel. Zool. Anz. 34 (1909) 180–192.
11. Dietz, E. Die Echinostomiden der Vögel. Zool. Jahrb., Supp. 12 (1910) 265–512.
12. Dive, G. H., and H. M. Lafrenais. A case of deposition of the eggs of Hepaticola hepatica in the human liver. With a note on the identity of the eggs by W. P. MacArthur. Journ. Roy. Army Med. Corps 43 (1924) 1–4.
13. Dollfus, R. Distomiens parasites de Muridae du genre Mus. Ann. de Parasit. Hum. et Comp. 3 (1925) 85–102; 185–205.
14. Faust, E. C. Human Helminthology. Philadelphia, Lea and Febiger (1929) xxii + 616, fig. 297.
15. Fülleborn, F. Über den Infektionsweg bei Hepaticola hepatica. Arch. f. Schiffs.- u. Trop.-Hyg. 28 (1924) 48–61.
16. Garrison, P. E. A new intestinal trematode of man (Fascioletta ilocana gen. nov., sp. nov.). Philip. Journ. Sci. § B 3 (1908) 385–393.
17. Garrison, P. E. Davainea madagascariensis (Davaine) in the Philippine Islands. Philip. Journ. Sci. § B 6 (1911) 165–175.
18. Grassi, B. Entwickelungscyclus der Taenia nana. Dritte Präliminarnote. Centralbl. f. Bakteriol. u. Parasitenk. 1. J. 2 (1887) 305–312.

19. HALL, M. C. Nematode parasites of mammals of the orders Rodentia, Lagomorpha, and Hyracoidea. Proc. U. S. Nat. Mus. **50** (1916) 1–258.

20. HALL, M. C. The adult taenioid cestodes of dogs and cats and of related carnivores in North America. Proc. U. S. Nat. Mus. **55** (1919) 1–94.

21. HILARIO, J. S., and L. D. WHARTON. Echinostoma ilocanum (Garrison): a report of five cases and a contribution to the anatomy of the fluke. Philip. Journ. Sci. § B **12** (1917) 203–211.

22. JANICKI, C. VON. Über zwei neue Arten des Genus Davainea aus celebesischen Saügern. Arch. d. Parasit. **6** (1902) 257–292.

23. JOYEUX, CH. Cycle evolutif de quelques cestodes. Recherches experimentales. Bull. Biol. France et Belgique, Supp. 2 (1920).

24. JOYEUX, CH. Hymenolepis nana et Hymenolepis fraterna. Ann. de Parasit. Hum. et Comp. **3** (1925) 270–280.

25. JOYEUX, CH., and J. G. BAER. Les cestodes rares de l'homme. Bull. Soc. Pathol. Exot. **22** (1929) 114–136.

26. LANE, C. Some Strongylata. Parasit. **15** (1923) 348–364.

27. MEGGITT, F. J., and K. SUBRAMANIAN. The tapeworms of rodents of the subfamily Murinæ, with special reference to those occurring in Rangoon. Journ. Burma Res. Soc. **17** (1927) 189–237.

28. MOMMA, K. Notes on modes of rat infestation with Hepaticola hepatica. Ann. Trop. Med. and Parasit. **24** (1930) 109–113.

29. NISHIGORI, M. On the life history of Hepaticola hepatica (second report). (In Japanese.) Journ. Med. Assoc. of Formosa, No. **247** (1925). Cited by Momma (1930).

30. ODHNER, T. Nordostafrikanische Trematoden grosstenteils vom Weissen Nil. Results of the Swedish Zoölogical Expedition to Egypt and the White Nile, 1901, under the direction of L. A. Jägerskiold, Uppsala (1910) 170 pp.

31. ODHNER, T. Echinostomum ilocanum (Garrison), ein neuer Menschen Parasit aus Ostasien. Zool. Anz. **38** (1911) 65–68.

32. RAILLIET, A. Sur la fréquence de la strongylose gastro-intestinale des léporides. Bull. Soc. de Med. Vet. **46** (1892) 195–198; discussion, 198–199. Cited by Hall (1916).

33. RANSOM, B. H. An account of the tapeworms of the genus Hymenolepis parasitic in man. U. S. Publ. Health and Mar.-Hosp. Serv., Hyg. Lab. Bull. **18** (1904) 1–138.

34. RILEY, W. A. A mouse oxyurid, Syphacia obvelata, as a parasite of man. Journ. Parasit. **6** (1919) 89–93.

35. RILEY, W. A., and W. R. SHANNON. The rat tapeworm, Hymenolepis diminuta, in man. Journ. Parasit. **8** (1922) 109–117.

36. SAEKI, Y. Experimental studies on the development of Hymenolepis nana. Summarized in Trop. Dis. Bull. **18** (1921) 112.

37. SAMBON, L. W. The elucidation of cancer. Journ. Trop. Med. and Hyg. **27** (1924) 124–174.

38. SANDGROUND, J. H. Speciation and specifity in the nematode genus Strongyloides. Journ. Parasit. **12** (1925) 59–80.

39. SANDGROUND, J. H. Biological studies on the life-cycle in the genus Strongyloides Grassi, 1879. Am. Journ. Hyg. **6** (1926) 337–388.

40. SCHÖBL, O. Bacteriological observations made during the outbreak of plague in Manila in 1912. Philip. Journ. Sci. § B 8 (1913) 409–426.

41. SCHWARTZ, B., and M. A. TUBANGUI. Uncommon intestinal parasites of man in the Philippine Islands. Philip. Journ. Sci. 20 (1922) 611–618.

42. SEURAT, L. G. Sur les Oxyures des Mammifères. Compt. Rend. Soc. Biol. 79 (1916) 64–68.

43. SEURAT, L. G. Sur les gongylonèmes du Nord-Africain. Compt. Rend. Soc. Biol. 79 (1916) 717–742.

44. SHIPLEY, A. E. Rats and their animal parasites. Journ. Econ. Biol. 3 (1908) 61–83.

45. SHORB, D. A. Experimental infestation of white rats with Hepaticola hepatica. Journ. Parasit. 17 (1931) 151–154.

46. SOUTHWELL, T. Notes on the larvæ of Moniliformis moniliformis (Brems.) found in African cockroaches. Journ. Parasit. 9 (1922) 99–101.

47. SOUTHWELL, T., and J. W. S. MACFIE. On a collection of Acanthocephala in the Liverpool School of Tropical Medicine. Ann. Trop. Med. and Parasit. 19 (1925) 141–184.

48. SPINDLER, L. A. On the occurrence of the rat tapeworm (Hymenolepis diminuta) and the dwarf tapeworm (Hymenolepis nana) in man in southwest Virginia. Journ. Parasit. 16 (1929) 38–40.

49. STILES, C. W. Illustrated key to the cestode parasites of man. U. S. Publ. Health and Mar.-Hosp. Serv., Hyg. Lab. Bull. 25 (1906) 1–104.

50. STILES, C. W., and A. HASSALL. Compendium of animal parasites reported for rats and mice (genus Mus). In: The rat and its relation to the public health. U. S. Treas. Dept. Publ. Health Bull. 30 (1910) 1–254.

51. STILES, C. W., and A. HASSALL. Key-catalogue of the worms reported for man. U. S. Publ. Health Serv. Hyg. Lab. Bull. 142 (1926) 69–196.

52. THOMAS, L. J. Studies on the life history of Trichosomoides crassicauda (Bellingham). Journ. Parasit. 10 (1924) 105–136.

53. TRAVASSOS, L. Revisão dos acantocephalos brazileiros. I. Fam. Gigantorhynchidæ Hamann, 1892 (2a. Nota previa). Brazil Med. N. 18, Anno 29 (1915) 137.

54. TRAVASSOS, L. Revisão dos acantocephalos brazileiros. Parte I. Fam. Gigantorhynchidae Hamann, 1892. Mem. Inst. Oswaldo Cruz 9 (1917) 5–62.

55. TUBANGUI, M. A. Trematode parasites of Philippine vertebrates, II: Two echinostome flukes from rats. Philip. Journ. Sci. 44 (1931) 273–283.

56. VAN CLEAVE, H. J. A critical study of the Acanthocephala described and identified by Joseph Leidy. Proc. Acad. Nat. Sci. Phila. 76 (1924) 279–334.

57. WEIDMAN, F. D. Hepaticoliasis, a frequent and sometimes fatal verminous infestation of the livers of rats and other rodents. Journ. Parasit. 12 (1925) 19–25.

58. WOODLAND, W. N. F. On the life-cycle of Hymenolepis fraterna (H. nana var. fraterna Stiles) of the white mouse. Parasit. 16 (1924) 69–83.

59. WOODLAND, W. N. F. On the development of the human Hymenolepis nana (Siebold, 1852) in the mouse; with remarks on "H. fraterna," "H. longior" and "H. diminuta." Parasit. 16 (1924) 424–435.

60. YOKOGAWA, S. A new nematode from the rat. Journ. Parasit. 7 (1920) 29–33.

61. YOKOGAWA, S. On the migratory course of Trichosomoides crassicauda (Bellingham) in the body of the final host. Journ. Parasit. 7 (1920) 80–84.

62. YOKOGAWA, S. The development of Heligmosomum muris Yokogawa, a nematode from the intestine of the wild rat. Parasit. 14 (1922) 127–166.

63. YORKE, W., and P. A. MAPLESTONE. The nematode parasites of vertebrates. Philadelphia: P. Blakiston's Son and Co. (1926) xi + 536, fig. 307.

ILLUSTRATIONS

[Drawn by V. V. Marasigan under the direction of the author.]

TEXT FIGURES

FIG. 1. *Euparyphium ilocanum.* *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)

2. *Euparyphium guerreroi.* *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)

3. *Euparyphium murinum* sp. nov. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view.

4. *Tænia tæniaformis.* *a*, Entire larva (after Sambon, 1924); *b*, scolex, anterior view; *c*, rostellar hooks.

5. *Raillietina garrisoni* sp. nov. *a*, Rostellar hooks; *b*, scolex; *c*, mature segment; *d*, gravid segment; *e*, egg.

6. *Hymenolepis diminuta.* *a*, Head; *b*, mature segment, dorsal view; *c*, gravid segment; *d*, egg.

7. *Hymenolepis nana.* *a*, Entire worm (from Ransom, 1904); *b*, rostellar hooks.

8. *Hymenolepis nana.* *a*, Head; *b*, mature segment, ventral view; *c*, gravid segment; *d*, egg.

9. *Strongyloides ratti*, entire worm. *a*, Anus, *oe*, œsophagus; *ov*, ovary; *v*, vulva.

10. *Trichosomoides crassicauda.* *a*, Mature female with male in uterus (after Hall, 1916), *m*, male worm; *v*, vulva; *b*, anterior end of mature male (after Thomas, 1924); *c*, egg.

11. *Hepaticola hepatica.* *a*, Anterior end of mature female (after Nishigori, from Yorke and Maplestone, 1926); *oe*, œsophagus; *v*, vulva; *b*, egg.

12. *Nippostrongylus muris.* *a*, Anterior end, lateral view; *b*, bursa, dorsal view.

13. *Syphacia obvelata.* *a*, Anterior end of female, lateral view; *b*, male, lateral view; *c*, posterior end of male, ventral view; *d*, posterior end of female, lateral view; *e*, egg. (All from Yorke and Maplestone, 1926.)

14. *Heterakis spumosa.* *a*, Anterior end of female, ventral view; *b*, posterior end of female, lateral view; *c*, posterior end of male, ventral view.

15. *Protospirura muricola.* *a*, Anterior end of female, ventral view; *b*, mouth, anterior view; *c*, posterior end of male, lateral view; *d*, posterior end of female, lateral view.

16. *Gongylonema neoplasticum*, anterior end, lateral view.

17. *Gongylonema neoplasticum.* *a*, Posterior end of male, ventral view; *b*, posterior end of female, lateral view.

18. *Rictularia whartoni* sp. nov. *a*, Anterior end of female, lateral view; *b*, anterior end of female, ventral view; *c*, posterior end of female, lateral view.

19. *Moniliformis moniliformis.* *a*, Anterior end, lateral view; *b*, hooks; *c*, egg.

NOTES ON DENGUE

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TWO TEXT FIGURES

The question of immunity in dengue has been discussed on innumerable occasions and much research work has been done on this phase of the disease. That immunity to the disease does occur was reported by Simmons, St. John, and Reynolds,[1] they reporting an effective resistance to reinfection in the case of thirty-six volunteers who had previously suffered from experimentally induced attacks of dengue. The immunity was proven in these cases at periods from one-half to thirteen months after the attack. This finding has been supported by experimental work carried on by the authors in six cases, all proving immune to the same strain with which they were originally infected twenty days previously. Following the proof of this immunity an attempt was made to reinfect these volunteers by feeding on them mosquitoes that had been infected by feeding on two other cases of dengue fourteen days previously. Reinfection was not accomplished in any of the six cases although they were all held twenty-one days after being bitten by the mosquitoes infected from an outside source.

This attempt to reinfect from outside sources was suggested by two cases that came under our observation and that, coupled with the fact that so many cases are immune to the virus with which they were originally infected, led us to suspect that there might possibly be different strains of dengue virus. We still believe in that possibility and attempts are being made to secure dengue-infected mosquitoes from other localities to prove or disprove this possibility.

The two cases mentioned above have the following histories:

1. This case was an officer's wife who arrived in the Philippine Islands in March, 1930, and has lived in Manila since

[1] Philip. Journ. Sci. 44 (1931) 174.

that time. She developed dengue in March, 1930, July, 1930, and October, 1930. All three attacks were typical and severe. There was a marked reduction in the leucocyte count, a crossing of the staff and segmented leucocytic curves and a temperature curve characteristic of the disease. In spite of the fact that transmission experiments were not carried out, all other findings strongly supported the belief that in this case three attacks of dengue occurred in less than seven months.

2. This case was a volunteer who was kept in a screened cubicle in Sternberg General Hospital for eight days, preliminary observation, during which time no symptoms of illness appeared. On the ninth day this volunteer was bitten by fifty mosquitoes selected at random from a cage of five hundred insects that had been infected from an experimentally induced case of dengue eighteen days previously. Three other volunteers were infected at the same time by the bites of other insects from the same lot and all three developed typical dengue. The case in discussion did not develop dengue after fourteen days, and forty-six mosquitoes of another infected lot were allowed to bite him. During three weeks observation following the second feeding no dengue occurred and he was discharged from hospital as immune. During his stay in hospital he had been transferred to a station 30 miles outside Manila and joined that station immediately after leaving hospital. Fourteen days after joining his new station he developed a typical case of dengue, as was shown by blood findings and clinical symptoms. There was no question as to the infectivity of the two lots of mosquitoes used in this case, and it is not believed that infection could have been produced as a result of feeding upon him the last lot of mosquitoes thirty-five days previously. No such prolonged incubation period has been observed, the vast majority of cases developing the disease within eight days after infection. There are only three possible conclusions in this case: (1) The extremely remote contingency that there was a long delayed incubation period after the second infection by mosquitoes; (2) that he lost a high degree of immunity in about twenty-nine days (allowing six days incubation period for the development of the disease); (3) that there are different strains of dengue virus.

Our experience and the experience of others lead us to believe that the first conclusion is practically untenable and that the second is not probable.

The first case related has no parallel insofar as we have been able to find, this patient having had three proven attacks of

dengue, severe in character, in a period of seven months. The evidence in these two cases certainly leads us to suspect the possibility of strains of dengue virus. Other cases not so striking as are these two tend to confirm our belief.

St. John [2] has devised a feeding cell so constructed that normal mosquitoes may be fed on other mosquitoes ground up and suspended in blood. In an attempt to attenuate the virus of dengue we have made serial feedings of normal *Aëdes ægypti* on macerated infected *Aëdes,* using fifty infected mosquitoes ground up in one cubic centimeter of nonimmune blood. These *Aëdes* infected by feeding were allowed an incubation period of fourteen days when they in turn were fed to normal *Aëdes* in the same manner as above. Five transfers were made and in all cases the insects were well filled with the blood mixture after feeding. Fourteen days after the third transfer dengue was produced in a susceptible volunteer, showing that transfer from mosquito to mosquito can be accomplished at least three times without the intervention of a human host. It is unlikely, of course, that this occurs in nature. The dengue produced by the bites of mosquitoes that had been infected by the third serial transfer from insect to insect was not modified insofar as we could determine, there being a reduction of the total white count to five thousand per cubic millimeter, a maximum temperature of 104° F., and a typical crossing of the segmented and staff forms of leucocytes. The subjective symptoms were as severe as in the ordinary attack of dengue. Fourteen days after the fifth serial transfer one hundred forty-five mosquitoes of this lot were allowed to bite a susceptible volunteer and did not produce dengue in twenty days. Subsequently this volunteer was bitten by a known infected lot of mosquitoes and developed typical dengue, showing that the volunteer was not immune and that the dengue virus had been lost in the five direct transfers from mosquito to mosquito or that it had been attenuated to such an extent that infection did not occur.

In another series of experiments attempts to attenuate the virus were made as follows:

Two volunteers were subjected to a preliminary observation period of one month in a screened cubicle. Dengue was produced experimentally in a third volunteer and on the first day of the fever 10 cubic centimeters of blood was removed, allowed to clot, the serum separated and immediately frozen at a tem-

[2] Op. cit., Plate 2.

perature of — 7° F. Twenty-four hours later 0.3 cubic centimeter of this serum was injected subcutaneously into the first volunteer and forty-eight hours after freezing 0.3 cubic centimeter of the same serum was injected into the second volunteer. The results obtained in the volunteer who received 0.3 cubic centimeter of the serum that had been frozen twenty-four hours were inconclusive in that the incubation period was too short to be entirely certain of the source of the infection, but in the volunteer receiving the virus frozen for forty-eight hours the disease developed on the seventh day and was typical, as shown by fig. 1.

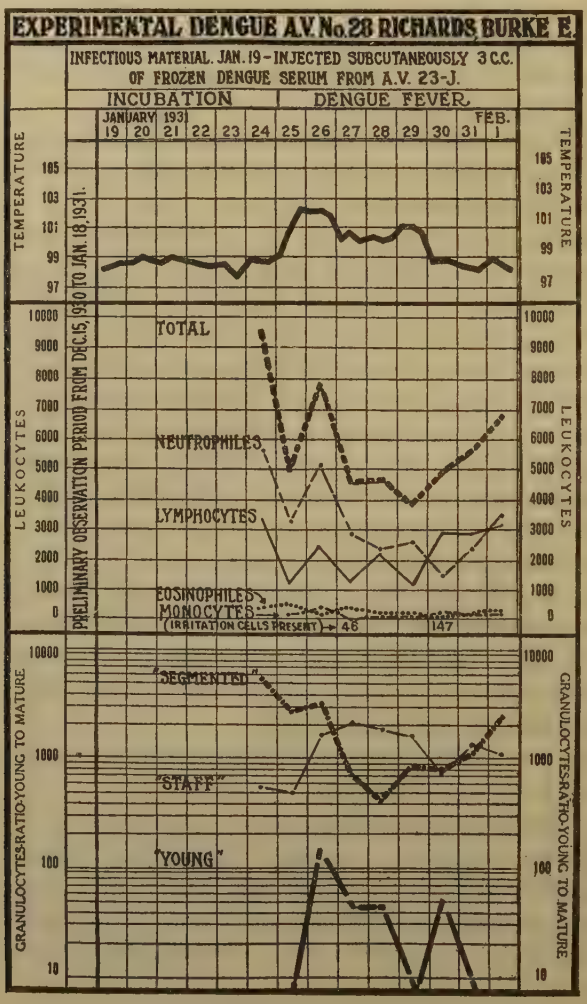

FIG. 1. Experimental dengue in American volunteer 28.

From this experiment it seems certain that the virus of dengue is affected little, if at all, by freezing at — 7° F. for a period of forty-eight hours.

A number of investigators have attempted to modify the course of dengue by the use of "convalescent" serum and all report failures. We have gone a step further. From each of four volunteers who had recovered from experimental dengue 10 cubic centimeters of plasma was removed on the fourteenth day after fever had disappeared. The pseudoglobulins were precipitated out of the pooled plasma, diluted with 0.85 per cent salt solution, and injected into a volunteer on the first day of dengue. No modification of the disease was noted. As shown by the chart, fig. 2, there was a primary and secondary rise of temperature, the height of the first reaching 103° F. and the

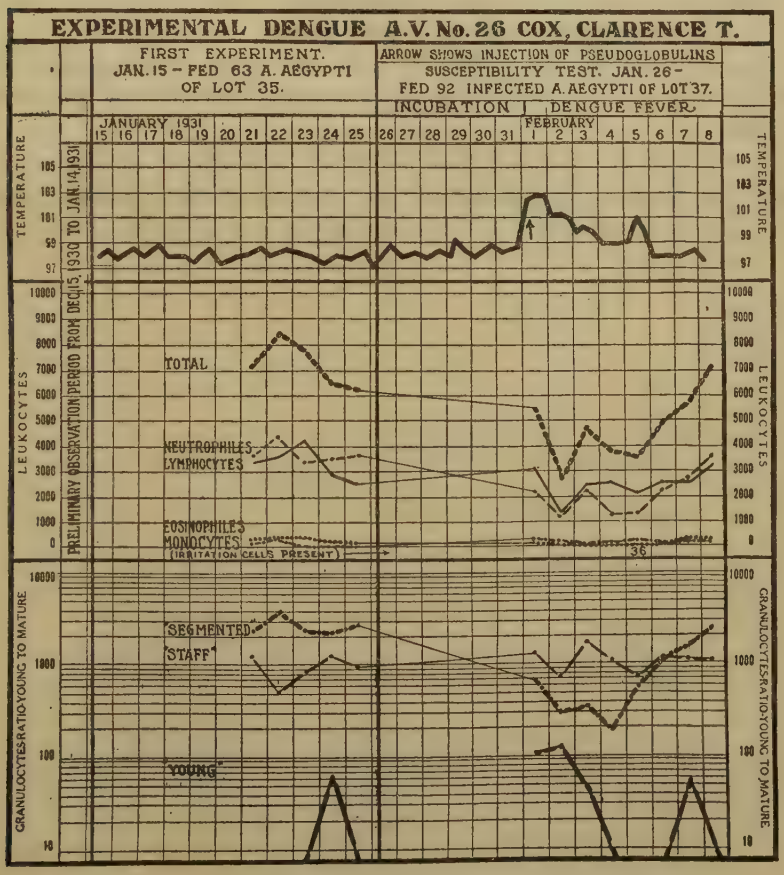

Fig. 2. Experimental dengue in American volunteer 26.

second 101° F. There was no discoverable abatement of the subjective symptoms, and none of the other symptoms seemed to be modified.

CONCLUSIONS

There is certainly an immunity to dengue fourteen days after an attack, both to the original infecting medium and to the virus of two outside cases.

Peculiarities in the behaviour of attacks of dengue, two cases of which are reported, coupled with the fact that immunity to the homologous strain has been proven numbers of times lead us to believe in the existence of "strains" of dengue virus.

The virus of dengue was tranferred from mosquito to mosquito by feeding for three transfers but was lost before the fifth transfer.

There was no discoverable attenuation of the virus as a result of the three transfers above mentioned.

Freezing dengue serum at — 7° F. for forty-eight hours did not destroy the virus nor was it attenuated insofar as we could discover.

Concentrated "immune bodies" from the serum of recovered cases of dengue do not affect the course of the disease when injected on the first day of the attack.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Experimental dengue in American volunteer 28.
2. Experimental dengue in American volunteer 26.

599

RESISTANCE OF DENGUE VIRUS

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FOUR TEXT FIGURES

Considering the enormous amount of work that has been done on dengue, it is rather surprising to note that comparatively little has been done on the resistance of dengue virus to outside influences. Cleland, Bradley, and McDonald [1] were able to produce dengue by inoculating infective blood which had been stored at refrigerator or room temperature for periods up to 172 hours. Blanc and Caminopetros [2] found that the addition of relatively small amounts of bile killed the virus in a short time. The virus has been preserved for periods of several days by different methods but almost always at low temperature. Drying of the virus seems to destroy it much more quickly than when it is kept moist and subjected to the same procedures. A temperature of 55° C. will render the virus noninfective within a period well under thirty minutes. It is certain that the virus resists the actions of the body fluids for an incubation period of six to nine or ten days and for at least three days after the onset of the disease. The mixing of convalescent sera and virus in serum does not seem to affect the infective power of the virus. It is well established that the virus lasts throughout the life of the infected *Aëdes*. We have demonstrated that the virus does not remain infective at the end of seven days at 37.5° C. in Tyrode's medium alone or with the addition of fresh testicular tissue from a rabbit. At just what period it lost its infectivity we are unable to say. We have already reported that freezing dengue serum at — 7° C. for a period of forty-eight hours does not seem to affect its infective power in the least.

Since it is well known that ultra-violet rays will destroy bacteria of many kinds in water and that X-rays will destroy the spores of many of the fungi, it was decided that it was worth

[1] Journ. Hyg. Cambridge 18: 217.
[2] Bull. Acad. Med. Athens 26: 37.

while to see if either of these agents would affect the virus of dengue in the body of the mosquito. As a preliminary step it was necessary to determine the resistance of *Aëdes ægypti* to the effects of X-ray and ultra-violet light. The insects were placed in a glass feeding cell, the open end of which was covered with mosquito netting to allow passage of the rays. In all exposures the number of insects used was twenty-five. In X-ray exposures the setting of the machine was constant; namely, 70 K.V., 5 M.A. and the distance from the center of the feeding cell was 30 centimeters. Only the time varied. Almost all of the mortality among the insects exposed occurred within a few minutes of the exposure and the mortality was not even roughly proportional to the length of exposure. For instance, when exposed to approximately one-twelfth erythema dose (30 seconds) four insects were dead in fifteen minutes and only two more had died at the end of twenty-four hours, one-sixth erythema dose (60 seconds) showed five dead in fifteen minutes and only two more dead in twenty-four hours, one-third erythema dose (90 seconds) showed eight and eleven dead, while one-half erythema dose (3 minutes) showed figures of two and naught. In this manner it was found that these insects could readily stand as much as two erythema doses with about 50 per cent living after twenty-four hours. A few lived for several days after this exposure.

TABLE 1.—*Aëdes ægypti exposed to X-ray.*

Setting.	Number exposed.	Time.	Distance.	Living at end of—	
				15 minutes.	24 hours.
		sec.	*cm.*		
70 KV–5 MA	25	30	30	21	19
70 KV–5 MA	25	60	30	20	18
70 KV–5 MA	25	90	30	17	14
70 KV–5 MA	25	180	30	23	23

In the same manner experiments were carried out to show the effects of ultra-violet on the normal *Aëdes*. The source of the ultra-violet was a Cooper Hewitt unit. The container for the mosquitoes in all experiments was a round glass feeding cell 14 centimeters deep with the open end toward the source of light covered by mosquito netting. In all cases there were 65 volts

across the arc of the mercury lamp and the current was 3.5 amperes.

This arc gave light of a total energy at 40 centimeters of 22 microwatts per square millimeter, or 0.000005 gram calories per second per square millimeter.

The light had the following spectral characteristics:

Millimicrons.	Per cent.	Microwatts per square millimeter.
185–1400	100	22
250–1400	78	17
310–1400	66	15
185–250	22	5
185–310	34	8
250–310	12	3

With an exposure of fifteen minutes at a distance of 40 centimeters, thirty-four insects showed no ill effects in seventy-two hours.

With thirty minutes exposure at 25 centimeters distance, of twenty-five mosquitoes two were dead at the end of the exposure and seven more were dead at the expiration of thirty minutes after the exposure. These deaths may have been due to heat or ultra-violet or both.

Of thirty-four mosquitoes exposed for one hour at a distance of 18 centimeters, with the light filtered through 4 millimeters of quartz and 1 centimeter of water and screened from the heat of the lamp, nine were dead in twenty-four hours and twenty-five were living but very weak. At the end of forty-eight hours thirty-three were dead and one was living but very weak.

With a forty-five minute exposure under the same conditions, of thirty mosquitoes two were living and twenty-eight dead at the end of twenty-four hours, and at the end of forty-eight hours all were dead.

Of twenty-five mosquitoes exposed for thirty minutes under the same conditions as related in the preceding experiment, fourteen were living at the end of twenty-four hours, three were living at the end of forty-eight hours, one was living at the end of seventy-two hours, and all were dead at the end of ninety-six hours. The fourteen living at the end of twenty-four hours were so weak that they were unable to feed on an animal.

To the ultra-violet that had passed through 4 millimeters of quartz, 1 centimeter of water and 2.5 millimeters of window glass which cut off at about 310 millimicrons, thirty *Aëdes* were

exposed for forty-five minutes. All were living after twenty-four hours, and eighteen of the thirty fed on a guinea pig. Five were dead at the end of forty-eight hours. No others died until after one hundred fourteen hours when twenty-four of the thirty were living and at the end of one hundred sixty-eight hours twenty-three were living.

Thirty *Aëdes* were exposed for fifteen minutes with the light filtered through 4 millimeters of quartz and 1 centimeter of water. After twenty-four hours, twenty-seven were living and nineteen fed on a guinea pig. No more died until the end of one hundred twenty hours, when a total of four were dead. None died between one hundred twenty and one hundred forty-four hours.

TABLE 2.—*Mosquitoes exposed to ultra-violet light.*

[Voltage 65 and current 3.5 amperes in all the following cases.]

Distance.	Time.	Filter.	Number exposed.	Living at end of—							
				15 minutes.	30 minutes.	24 hours.	48 hours.	72 hours.	96 hours.	144 hours.	168 hours.
cm.	*min.*										
40	15	0	34	------	------	------	------	34	------	------	------
25	30	0	25	23	16	------	------	------	------	------	------
18	60	4 mm quartz and 1 cm water.	34	------	------	25	1	------	------	------	------
18	45	4 mm quartz and 1 cm water.	30	------	------	2	0	------	------	------	------
18	30	4 mm quartz and 1 cm water.	25	------	------	14	3	1	0	------	------
18	45	4 mm quartz, 1 cm water, and 2.5 cm window glass.	30	------	------	30	25	------	------	24	23
18	14	4 mm quartz and 1 cm water.	30	------	------	27	------	------	------	26	------

From these experiments it was thought that the maximum dose of X-ray for mosquitoes was two erythema doses if the insects were to be able to feed on a volunteer after exposure

and that the maximum exposure to ultra-violet would be about fifteen minutes.

Four volunteers, A.V. 34–Immordino, A.V. 35–Hawley, A.V. 36–Cook, and A.V. 37–Small were admitted to screened cubicles in Sternberg General Hospital February 27, 1931, and submitted to an observation period of thirteen days, during which time they showed no evidence of illness. All were recent arrivals in the Philippine Islands and gave no history of dengue. At 8 a. m. on the fourteenth day four lots of proven infective mosquitoes were treated as follows:

Lot 1 consisted of forty-six mosquitoes. They were exposed for fifteen minutes to ultra-violet produced by a mercury arc lamp with 65 volts crossing the arc and showing a current of 3.5 amperes and with a distance of 40 centimeters from the front of the feeding cell, the light being filtered through a cell of 4 millimeters of quartz and 1 centimeter of water. This cell passed light from 185 to 1,400 millimicrons wave length. Most of the insects congregated at the back of the feeding cell during the exposure so that the distance was about 50 centimeters from the arc to where the majority of the insects congregated. Many of the insects fell to the bottom of the feeding cell during the exposure but ten minutes later all had apparently recovered. One hour later three had died, seventeen refused to feed, and twenty-six fed on A.V. 34–Immordino. Six days later this volunteer developed typical dengue as shown by the chart (fig. 1). Of this lot of mosquitoes sixteen survived for nine days.

Lot 2 consisted of forty-six infected *Aëdes* and were subjected to the same conditions as outlined in lot 1, except that a window-glass filter, passing light from 310 to 1,400 millimicrons wave length, was inserted between the source of ultra-violet and the insects. Exposure time was fifteen minutes and distance 40 centimeters. One hour later two were dead, eighteen refused to feed, and twenty-six fed on A.V 36–Cook. Five days later this volunteer developed dengue as shown by the chart (fig. 2). Twenty-seven of these insects survived for nine days.

Lot 3 consisted of forty-six infected *Aëdes* that were treated as follows: An X-ray machine was set at 70 K.V., 5 M.A. and with a distance of 30 centimeters. The insects were radiated for six minutes with this setting, which exposed them to approximately one erythema dose. One hour later seven were dead, fifteen refused to feed, and twenty-four fed on A.V. 35–Hawley,

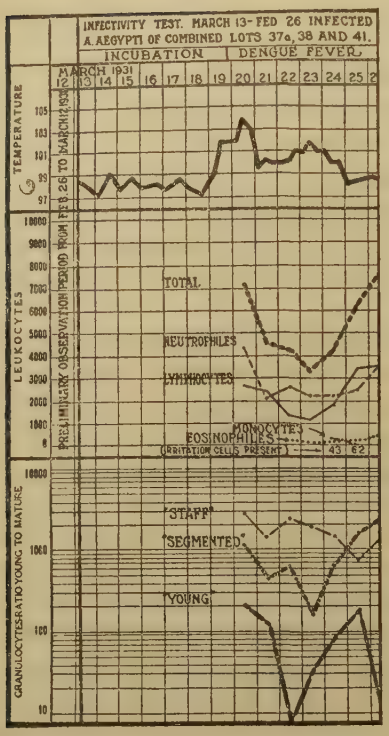

FIG. 1. Chart of American volunteer 34–Immordino.

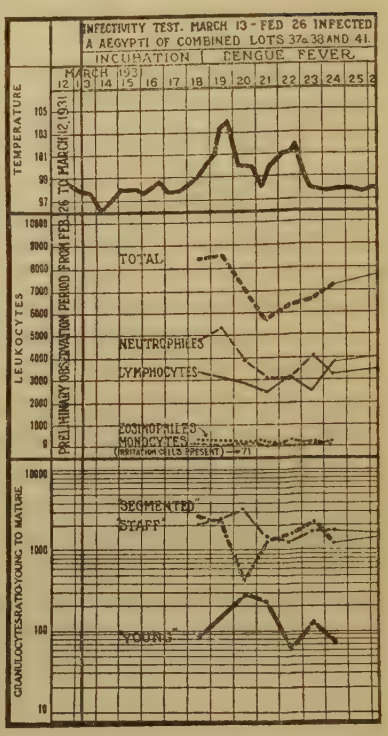

FIG. 2. Chart of American volunteer 36–Cook.

who developed dengue six days later, as shown by the chart (fig. 3). Seven mosquitoes survived nine days.

Lot 4 consisted of forty-two infected *Aëdes* that were subjected to X-ray radiation equal to approximately two erythema doses, the setting of the machine being the same as for lot 3 and the time doubled. At the end of one hour six were dead, seven refused to feed, and twenty-nine fed on A.V. 37–Small, who developed dengue on the sixth day, as shown in the chart (fig. 4). Only one mosquito survived nine days.

The insects showed great perturbation while being treated with X-ray and ultra-violet unscreened, but were not visibly disturbed by treatment with ultra-violet when a window-glass screen was interposed.

The disease produced in the above-mentioned volunteers was not modified insofar as we could determine.

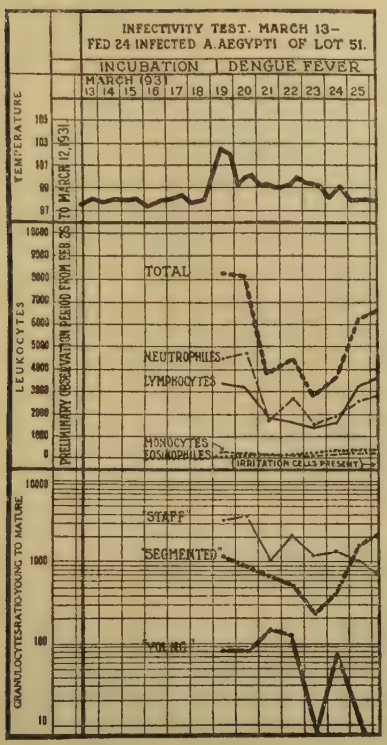

FIG. 3. Chart of American volunteer 35–Hawley.

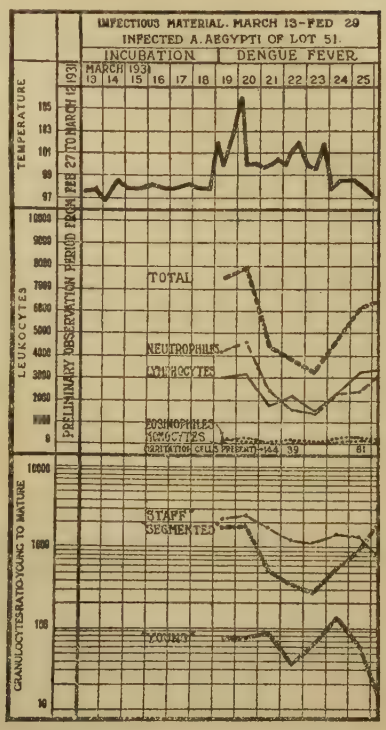

FIG. 4. Chart of American volunteer 37–Small.

CONCLUSIONS

Aëdes ægypti shows much greater resistance to the effects of ultra-violet light and X-ray than does man.

Dengue virus does not appear to be adversely affected by relatively large amounts of X-ray and ultra-violet, despite the fact that it is well known that several species of bacteria and molds are affected by ultra-violet light and that several of the fungi and their spores are affected by X-ray.

It seems apparent that no good can be hoped for in the treatment of dengue cases by the use of either of the above-mentioned forms of energy.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Chart of American volunteer 34–Immordino.
2. Chart of American volunteer 36–Cook.
3. Chart of American volunteer 35–Hawley.
4. Chart of American volunteer 37–Small.

THE ATTEMPTED CULTIVATION OF MYCOBACTERIUM LEPRÆ

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ONE PLATE

The immediate activator of the present studies was the reported cultivation of *Mycobacterium lepræ* in 1929 by Wherry [1] in Manila and by Shiga[2] in Chosen, Korea.

In Wherry's studies, made in the School of Hygiene and Public Health in Manila, he reported microscopic proliferation of *M. lepræ* in cultures from three cases. One loopful of blood, obtained by the routine "snip" method, was inoculated into the water of syneresis of slants of glycerinized ovomucoid yolk agar, to which had been added 1 to 2 drops of autoclaved oleic acid and 1 to 2 drops of autoclaved 10 per cent dextrose solution in distilled water. Wherry reports that the best growth was obtained in cultures that were kept for a month at 35 to 37° C. at partial oxygen tension (diminished O_2 and increased CO_2), a condition that was brought about by attaching the culture tubes by means of rubber tubing to agar slants inoculated with *B. coli.* After one month at partial oxygen tension, a fine syringe needle was inserted through the connecting rubber tubing and the point of the needle buried in the cotton plug of

[1] Journ. Inf. Dis. 46 (1930) 263.
[2] Journ. Chosen Med. Assoc. 19 (1929) 1.

the culture tube, thereby establishing an O_2 and CO_2 environment.

Shiga used, as the source of his inoculum, excised leprous nodules that were ground in a 5 per cent solution of sulphuric acid. The suspension was next incubated for twenty minutes, and then centrifuged; the sediment was used for inoculation. The medium employed by Shiga consisted of 4 per cent glycerin bouillon potato wedges placed in Roux test tubes (reaction p_H 6.8 to 7.0) with the lower portion of the tube, below the constriction, filled with 4 per cent glycerin bouillon. Shiga reported growth of *M. lepræ* after two months of aërobic incubation at 37° C., but says: "Die Kolonien auf Kartoffeln sind zart, dünn und unsichtbar." However, he says that upon transplant to glycerin agar small, but visible, colonies developed.

The total number of cases cultured by us was twelve; all were active, recently admitted cases of leprosy at San Lazaro Hospital, Manila, that had received no treatment, with the exception of cases 11 and 12. We wish here to record our appreciation of the fine spirit of coöperation manifested by Doctor Velasco in placing these cases at our disposal. In the appendix will be found a brief description of each case, and the direct smear findings.

In all of the cases, the method of obtaining culture material was the same. The skin over the leprous lesion was treated with iodine, followed by alcohol; then the area to be incised was grasped with sterile forceps, and the incision made with a sharp sterile knife. Next, the interior was scraped with the tip of a second sterile knife, and blood containing lepra bacilli was obtained on the edge of the knife. In many instances, pieces of tissue were also obtained. By means of a sterile platinum loop a loopful of blood or a piece of tissue was transferred immediately to the water of syneresis in the culture tube; inoculations on the surface of the slant, just above the water of syneresis, were made as well. In each case, direct smears were made from blood or tissue scrapings approximately equal in amount to that employed as the inoculum of a single culture tube. Direct smears, as well as smears from cultures, were stained with steaming, and with unwarmed, carbol-fuchsin, followed by acid alcohol and a counter stain of dilute Löffler's methylene blue.

The media employed in our cultural studies were as follows: (1) 4 per cent, 5 per cent, and 6 per cent glycerin ovomucoid yolk agar containing oleic acid and dextrose (Wherry medium);

(2) 4 per cent glycerin bouillon Irish potato wedges (Shiga medium); (3) 4 per cent glycerin bouillon lakatan (banana) wedges; (4) 4 per cent glycerin bouillon saba (banana) wedges; (5) 4 per cent glycerin bouillon sweet potato wedges; (6) 4 per cent glycerin bouillon gabi (tuber) wedges; (7) 4 per cent glycerin bouillon ubi (tuber) wedges; (8) lakatan agar slants (p_H 7.2), made by mixing one part of ground 4 per cent glycerin lakatan with two parts of 2.5 per cent meat infusion agar; (9) serum glucose cystine agar slants and columns (Francis),[3] to which in certain series 1 drop of normal human serum was added to the water of syneresis, and to others 1 drop of syphilitic serum; and (10) infant human brain agar slants, made by mixing one part of ground 4 per cent glycerin brain with one part of 3 per cent nutrient agar, plus 2 drops of 10 per cent dextrose solution and 2 drops of nucleic acid to each 3 cubic centimeters of medium. In addition, slants of plain glycerin and blood agar, as well as of Löffler's blood serum, were employed as controls.

All of our cultures, primary cultures as well as transplants, were incubated continuously at 37° C. for periods ranging from eleven weeks to seven months, with the exception of one series that was kept at room temperature. In all instances, parallel culture tubes were incubated (*a*) aërobically, uncapped and covered with a rubber cap; (*b*) anaërobically, by means of pyrogallic acid and potassium hydroxide; (*c*) partial oxygen tension and increased CO_2. In certain of the partial oxygen tension series, the original *B. subtilis* or *B. coli* was allowed to remain unchanged during the entire period of incubation; in others, freshly inoculated slants were attached to the culture tubes every twenty-four hours. In other series, after four to six weeks incubation under diminished oxygen and increased CO_2, oxygen was admitted by inserting a fine needle through the connecting rubber tubing, and burying the point in the cotton stopper of the culture tube.

A detailed analysis of the cultural findings in each case that we studied will not be attempted. Rather, we will endeavor briefly to review our results as a whole, with illustrative references to certain typical cases.

Aërobic cultures, both capped and uncapped, have shown a shorter persistence of *M. lepræ*, in smaller numbers, than have

[3] Public Health Reports 38 (1923) 1396.

the comparable partial tension and anaërobic cultures. Aërobic cultures on glycerin bouillon lakatan wedges, glycerin bouillon saba, glycerin bouillon sweet potato, glycerin bouillon gabi, glycerin bouillon ubi, lakatan agar slants, serum glucose cystine agar slants, as well as slants of plain glycerin and blood agar and Löffler's blood serum, have revealed a quite regular disappearance of the implanted acid fasts within two weeks of incubation at 37° C., and in a shorter time at room temperature. There is a relatively brief persistence of the microörganisms with typical staining reaction, followed by a rather rapid loss of acid-fastness, and then by autolysis. Somewhat irregular persistence of *M. lepræ* for a longer period of time was observed in certain cases in aërobic 37° C. cultures on infant human brain agar, glycerin ovomucoid yolk agar (Wherry medium), and glycerin bouillon Irish potato wedges; in cases 1, 4, 5, 6, 7, 8, 9, and 10, the original aërobic cultures revealed no acid fasts after one month at 37° C. In case 2 (Claudio Quinto), in which direct smears from the lesion showed enormous numbers of *M. lepræ*, a smear from a fragment of blood and tissue scraping planted on an aërobic slant of infant human brain agar revealed brightly staining, typical acid fasts in pure culture at the end of forty-eight days' incubation at 37° C. The acid fasts were not, however, in as large numbers as in the comparable partial tension culture, and they disappeared on longer incubation. In the same case 2, a comparable smear from the same amount of inoculum on aërobic glycerin bouillon Irish potato showed somewhat smaller numbers of equally typical acid fasts in pure culture upon forty-three days' incubation at 37° C., which disappeared on further incubation; whereas a comparable smear from the same amount of inoculum in the water of syneresis and on the surface of a slant of glycerin ovomucoid yolk agar (Wherry medium) revealed no acid fasts at the end of forty-three days' incubation at 37° C. On the other hand, in case 3 (Pablo Carpio), which likewise showed *M. lepræ* in enormous numbers in direct smears from the lesion, a smear from the glycerin bouillon Irish potato incubated for forty-three days at 37° C. showed a few scattered, rather poorly staining, partially autolyzed acid fasts in pure culture, whereas a comparable smear from the same amount of inoculum in a slant of glycerin ovomucoid yolk agar incubated for the same time at 37° C., showed somewhat larger numbers of brightly staining, typical acid fasts in pure culture, which disappeared upon longer incubation. Continuous incubation at 37°

C. for five to seven months of all of our original aërobic cultures has not alone failed to reveal any evidence of multiplication of the implanted *M. lepræ,* but in the extremest instances of persistence of the microörganisms in aërobic cultures no acid fasts were found after two months' incubation. Aërobic transplants to the same medium, as well as to all other media employed in our studies, made at weekly intervals and at the end of four and six weeks' continuous incubation, from all original aërobic cultures that showed a persistence of *M. lepræ* in pure culture, have consistently failed to reveal any evidence of multiplication of the transferred *M. lepræ.* Moreover, in aërobic transplants, the numbers of *M. lepræ* have consistently diminished, and in second and third transplants the acid fasts have entirely disappeared.

In all of the twelve cases studied, partial oxygen tension cultures revealed a longer persistence of *M. lepræ,* in larger numbers, and with more typical morphological and staining characters, than did the corresponding aërobic cultures. Usually, cultures made anaërobic with pyrogallic acid and potassium hydroxide yielded a longer persistence of *M. lepræ* in larger numbers, in larger clumps and more vividly acid fast, than did the corresponding partial oxygen tension cultures; in partial tension cultures, *M. lepræ* appeared somewhat shorter than in anaërobic cultures. Acid fasts, both granular and solid forms, were quite regularly found in the largest numbers if smears were made from a fragment of blood or tissue implanted in the water of syneresis, or on the surface of the medium just above the water of syneresis. However, in no instance in any of our partial tension and anaërobic cultures, originals as well as in transplants, was observed any evidence of microscopic, or undisputable microscopic, multiplication of *M. lepræ.* As in the aërobic series, continuous incubation was employed at 37° C. and at room temperature for periods ranging from five to seven months. In both the partial tension and in the anaërobic series, the best and longest persistence of *M. lepræ* was obtained on glycerin ovomucoid yolk agar, glycerin bouillon saba wedges, infant brain agar, and in one instance 4 per cent glycerin chicken bouillon sweet potato, at 37° C. In certain of the original anaërobic and partial tension cultures on these media *M. lepræ* have been found in large numbers in pure culture after ninety-six days of continuous incubation, the extreme instance being one hundred fifty-eight days. First transplants have revealed

still considerable, but smaller, numbers of *M. lepræ* in pure culture after twenty-four to ninety-six days incubation; and second transplants have showed a persistence of still smaller numbers of *M. lepræ* in pure culture for shorter periods of time, ranging from twenty-four to thirty-six days. Aërobic transplants from partial oxygen tension and anaërobic original cultures revealed a persistence of *M. lepræ* in decreasing numbers for a few weeks, with diminished acid-fastness, and their complete disappearance within one month or less. On the other hand, partial oxygen tension transplants from original partial oxygen tension cultures, anaërobic transplants from anaërobic original cultures, as well as partial oxygen tension transplants from anaërobic cultures and anaërobic transplants from partial oxygen tension cultures, all revealed a longer persistence, in larger numbers, of more typical and more brightly acid-fast bacilli.

In the case of our partial oxygen tension series of cultures, originals as well as transplants, no demonstrable difference in the persistence of *M. lepræ,* nor in its numbers, was noted in cultures incubated continuously with the same original tube of *B. subtilis* or *B. coli* attached, and in those to which fresh tubes of *B. subtilis* or *B. coli* were attached daily. Again, no significant difference was observed in the persistence of *M. lepræ* when transplants were made from original cultures at weekly intervals, at the end of four to six weeks' continuous incubation, and after two to four months of continuous incubation. However, the longest persistence of *M. lepræ* in large numbers was observed by us in an original partial tension culture made from case 9. This culture, made by planting a loopful of bloody scrapings on the surface of a 4 per cent glycerin chicken bouillon sweet potato wedge just above the glycerin, was incubated continuously at 37° C. for eighty-eight days at partial oxygen tension, with the original slant of *B. coli* attached. At the end of this period, oxygen was admitted to the culture, according to the method suggested by Wherry,[4] by inserting a needle through the connecting rubber tubing into the cotton plug of the culture tube. The culture was then reincubated at 37° C. for another seventy days, making a total incubation period of one hundred fifty-eight days, at the end of which time the culture was examined. A smear made from a fragment of the dark brown inoculum revealed, on a five-minute search,

[4] Loc. cit.

twenty clumps of vividly acid fast, granular, *M. lepræ* in pure culture. The majority of the clumps consisted of from four to about thirty *M. lepræ*, with a few scattered groups of two to three members.

As illustrative of our anaërobic results, we might cite certain of our cultural findings on case 6. At the time of making the original cultures from this case, direct smears revealed *M. lepræ* in relatively small numbers, an average of about ten acid fast bacilli per oil-immersion field; the majority were in small clumps of six to eight members. A platinum loopful of bloody scrapings from the incised lesion was immediately planted on the surface of a glycerin bouillon saba wedge, just above the glycerin, and the culture was made anaërobic with pyrogallic acid and potassium hydroxide. At the end of twenty-six days continuous incubation at 37° C., the tube was opened and a smear was made from a small fragment of the implanted bloody scraping. This smear revealed in pure culture, quite large numbers of typical *M. lepræ*, granular and solid forms, averaging from thirty to forty per oil-immersion field; the majority of the acid fasts were in clumps of from fifteen to about one hundred members. In as much as the direct smear from the lesion had shown only about ten *M. lepræ* per oil-immersion field, the majority in small clumps of six to eight members, these cultural findings seemed somewhat encouraging. They might be interpreted as suggesting that the implanted *M. lepræ* had undergone a certain amount of preliminary multiplication; again, the results might be explained by assuming that the loopful of inoculum used for this particular culture tube contained a larger number of *M. lepræ* than did the material used for making the direct smear. Which of the two interpretations is the correct one, we do not know; it seems to us, however, that the second alternative is at least equally as valid as the first. At any rate, the subsequent history of this original culture would indicate that if a certain initial proliferation of *M. lepræ* did occur, this mulplication was not sustained. On examination of the culture at the end of fifty days continuous anaërobic incubation at 37° C., a smear made from approximately the same-sized fragment of implanted blood scraping revealed acid fasts in smaller numbers, averaging from eight to ten per oil-immersion field, and after ninety-six days of continuous anaërobic incubation, no *M. lepræ* were found. Analogous anaërobic and partial oxygen tension cultures made on 6 per cent glycerin ovomucoid yolk agar and on glycerin Irish potato wedges at

the same time as the original anaërobic saba wedge culture was made, revealed only a few scattered acid fasts after twenty-six days at 37° C., and at the end of fifty days' incubation no *M. lepræ* were found.

An anaërobic glycerin bouillon saba wedge transplant 1, was made from the original anaërobic saba culture at the end of twenty-six days' incubation at 37° C., an amount of inoculum being employed that was approximately the same as in making the smear. After forty-nine days at 37° C., this transplant 1 revealed in pure culture an average of about ten *M. lepræ* per oil-immersion field. The majority of the acid fasts were of the granular type, but scattered, longer, thinner, solid forms occurred; clumps of from twenty to fifty plus brightly staining acid fasts were found. Anaërobic transplant 2 on glycerin bouillon saba, made from anaërobic saba transplant 1 at the end of forty-nine days at 37° C., revealed on eleven days' incubation at 37° C. only one granular acid fast; on twenty-five day's incubation, as well as at the end of three months, no *M. lepræ* were found.

Anaërobic transplant 1 to a glycerin Irish potato wedge, made from the original glycerin bouillon saba wedge after twenty-six days of anaërobic incubation, revealed only a few, scattered, feebly acid fast *M. lepræ* in pure culture after forty-nine days' incubation at 37° C., and by the end of ninety-five days' incubation no acid fasts could be found. Anaërobic transplant 1 to the water of syneresis of a 6 per cent glycerin ovomucoid yolk agar slant, made from the original anaërobic glycerin bouillon saba culture after twenty-six days of incubation, revealed no acid fasts at the end of forty-nine, sixty-three, and ninety days' incubation. Partial oxygen tension transplant 1 on glycerin Irish potato, glycerin bouillon saba wedges, and into the water of syneresis of glycerin ovomucoid yolk agar slants, made from the original anaërobic glycerin bouillon saba culture after it had been incubated twenty-six days, revealed a few scattered *M. lepræ* in pure culture after forty-nine days at 37° C., but on later examinations no acid fasts could be found.

SUMMARY

The longest persistence of *M. lepræ* in pure culture, and in large numbers, that was observed by us was one hundred fifty-eight days. This occurred in an original partial oxygen tension culture from case 9 on 4 per cent glycerin chicken bouillon sweet

potato, incubated at 37° C. for eighty-eight days, with the original tube of *B. coli* attached. At the end of this time, oxygen was admitted according to the method suggested by Wherry,[5] and the culture was reincubated for another seventy days.

In the remaining eleven cases, somewhat longer persistence in pure culture of larger numbers of somewhat more typical appearing *M. lepræ* was obtained at 37° C. under anaërobic conditions (pyrogallic acid and potassium hydroxide) than at partial oxygen tension. Of the media employed by us, the most favorable were glycerinized ovomucoid yolk agar slants (Wherry medium), glycerin bouillon saba wedges, and infant brain agar slants. In certain of such anaërobic cultures, *M. lepræ* have been found in pure culture, and in large numbers, after ninety-six days of continuous incubation at 37° C.

The next best persistence of *M. lepræ* in pure culture was obtained in partial oxygen cultures on the same media at 37° C. In certain of such cultures, *M. lepræ* have been found in large numbers after ninety-six days' continuous incubation, and in one case after one hundred fifty-eight days. No demonstrable difference was observed in cultures to which a fresh tube of *B. coli* or *B. subtilis* was attached every twenty-four hours, and in cultures to which the original tube of *B. coli* was allowed to remain attached during the entire period of incubation.

The shortest persistence of *M. lepræ,* in the smallest numbers, was obtained in our aërobic cultures, in which an irregular persistence of *M. lepræ* for from fourteen to forty-three days was observed.

First, second, and third transplants, aërobic, partial oxygen tension and anaërobic, have shown a progressive diminution in the number of *M. lepræ,* with a disappearance of acid fasts in the third transplants. No demonstrable difference in the persistence of *M. lepræ* was observed when transplants were made at weekly intervals, at intervals of three to six weeks, and at intervals of two to three months.

The addition of cystine in 0.1 per cent concentration, of normal human serum, and of syphilitic serum appears to exert no favoring action upon the persistence of *M. lepræ* in cultures.

In none of our original cultures and transplants, which were incubated at 37° C. for periods ranging from four to seven months, did we obtain any macroscopic evidence of multiplica-

[5] Loc. cit.

tion of the implanted *M. lepræ*, nor did we obtain any indisputable microscopic evidence of proliferation.

APPENDIX; DESCRIPTIONS OF CASES

Case 1—Vicente Arriola.

Age 32. Male. Single. Filipino. Occupation, fireman. Family history for leprosy negative. First sign and symptom, anæsthesia on left knee six months ago. Never received antileprotic treatment. Physical condition good. Local lesions are numerous, small, pale pinkish, slightly elevated macular patches all over trunk, buttocks, upper extremities, thighs, the left and lower portion of the face. No nodules. Slight infiltrations in face, ear lobes, and left knee.

Summary.—A case of moderate cutaneous, slight neural leprosy of six months' duration. Cultures made from left malar eminence.

Direct smear.—*M. lepræ* in small packets and singly; bacilli average about 15 in number per oil-immersion field and are bright staining.

Case 2—Claudio Quinto.

Age 40. Male. Married. Filipino. Occupation, quarryman. Family history for leprosy negative. First sign and symptom, anæsthesia on both legs, preceded by nodules, five years ago. Never received antileprotic treatment. Physical condition fair. Local lesions are dry, wrinkled, macular patches on trunk and thigh; extensive infiltrations on ears and face, less extensive on trunk, buttocks, and extremities. Indurated, thickened skin on legs and feet. Anæsthesia extensive on both extremities.

Summary.—A case of advanced cutaneous and advanced neural leprosy of five years' duration. Cultures made from right ear.

Direct smear.—Enormous numbers of bright-staining *M. lepræ*, the majority in large or small masses, but with many single acid-fast rods. The number of bacilli averages over 100 per oil-immersion field.

Case 3—Pablo Carpio.

Age 19. Male. Single. Filipino. No occupation. Family history for leprosy negative. First sign and symptom, anæsthesia on forearm and right elbow, six years ago. Never received antileprotic treatment. Physical condition fair. Local lesions are extensive; infiltrations on ear, face, nipples, hands, and feet; no macules. Beginning nodular pigmentation and tænia of the ear, medial aspect of palm, forehead, and feet; indurated, thickened skin on legs.

Summary.—Advanced cutaneous and advanced nodular leprosy of six years' duration. Cultures made from right ear and forearm.

Direct smear.—Enormous numbers of bright-staining *M. lepræ*, the majority in large or small masses, but with many single acid-fast rods. Bacilli average over 150 per oil-immersion field.

Case 4—Juana Falcone.

Age 36. Female. Single. Filipino. No occupation. Family history for leprosy negative. First sign and sympton was a slight numbness over right leg one year ago. Never received antileprotic treatment. Physical condition poor. Local lesions are macules, numerous on back, anterior chest wall, and epigastrium. Infiltration diffuse on face, ears, fingers,

and toes. Nodules, large and small, on elbows, forearms, buttocks, arms, and lower extremities. Maculopapular areas on lower and upper extremities.

Summary.—Advanced cutaneous and slight neural leprosy of one year's duration. Cultures made from right ear lobe.

Direct smear.—Relatively small numbers of brightly staining *M. lepræ*, practically all single. Becilli average about 5 per oil-immersion field.

Case 5—Gregorio Jabines.

Age 44. Male. Widower. Filipino. Occupation, merchant. Family history for leprosy negative. First sign and symptom was one, large reddish macule on abdominal wall two years ago. Never received antileprotic treatment. Condition fair. Local lesions are macules on face, ears, chest, abdomen, back, lower and upper extremities, and nape of neck. Nodule on ear; no infiltrations.

Summary.—Moderate advanced macular leprosy of two years' duration. Cultures made from arm.

Direct smear—M. lepræ in moderately large numbers averaging about 30 per oil-immersion field. Majority of bacilli are single, with occasional small masses of four to eight members. *M. lepræ* stains more feebly than in cases 1 and 4.

Case 6—Rosa Musni.

Age 14. Female. Single. Filipino. No occupation. Family history for leprosy negative. First sign and symptom was anæsthesia of forearm one year ago. Never received antileprotic treatment. Condition good. Local lesions are macules on cheeks, ears, chest, abdomen, and right forearm. Infiltrations on ear. No nodules. Ichthyosis, both legs.

Summary.—Moderate cutaneous and slight neural leprosy of one year's duration. Cultures made from left ear.

Direct smear.—M. lepræ in relatively small numbers, averaging about 10 per oil-immersion field. Majority are in small masses of six to eight members. *M. lepræ* stains slightly more brightly than in case 5.

Case 7—Laynes.

Age 18. Male. Single. Filipino. Occupation, laborer. Family history for leprosy negative. First sign and symptom was redness of face and thickening of nose and ears three months ago. Never received antileprotic treatment. Condition fair. Local lesions are macules, big and depigmented, on trunk, arms, and thighs. Infiltration extensive on face and ear. No nodules.

Summary.—Macular, moderately advanced cutaneous, and slight neural leprosy, of three months' duration. Cultures made from left ear.

Direct smear.—M. lepræ in moderate numbers, averaging about 35 per oil-immersion field. Majority are in masses of fifteen to twenty-five members; bacilli stain brightly.

Case 8—Yep Heng.

Age 25. Male. Single. Chinese. Occupation, carpenter. Family history for leprosy negative. First sign and symptom were reddish, anæsthetic patches on internal aspect of right knee about one and a half years ago. Never received antileprotic treatment. Condition good. Local le-

sions are macules on face, ears, chest, abdomen, back, nape of neck, and upper extremities. No infiltration; no nodules.

Summary.—Moderate macular leprosy of about one-half year's duration. Cultures made from cheek.

Direct smear.—*M. lepræ* in relatively small numbers, averaging about 15 per oil-immersion field. Single acid fasts predominate, with occasional clumps of eight to ten members. *M. lepræ* stains rather feebly.

Case 9—Leopoldo Duque.

Age 16. Male. Single. Filipino. Occupation, farmer. Family history for leprosy reveals a leprous father. First sign and symptom were whitish areas on right knee about one year ago, after recovery from measles; also large areas of same character on abdomen. Never received antileprotic treatment. Condition fair. Local lesions are macules on cheeks, abdomen, back, lumbar region, right arm, and anterior aspect of thighs. Infiltrations in alæ nasæ and cheeks. No nodules. Ulnar and common perineal nerves thickened.

Summary.—Moderate macular and moderate neural leprosy of about one year's duration. Cultures made from ear.

Direct smear.—*M. lepræ* in relatively small numbers, averaging about twelve per oil-immersion field. Majority of bacilli are single, with occasional clumps of eight to twenty members. *M. lepræ* stains brightly.

Case 10—Feliciano Duque.

Age 42. Male. Married. Filipino. Occupation, farmer. Family history for leprosy reveals a leprous brother-in-law. First sign and symptom were numbness over both feet about fourteen months ago. Never received antileprotic treatment. Condition fair. Local lesions are macules on cheeks, chest, abdomen, back, lumbar region, both arms, buttocks, and anterior aspect of thighs. Infiltrations on both ears and cheeks. No nodules. Ulnar, great auricular, and common perineal nerves thickened.

Summary.—Moderate macular and moderate neural leprosy of about fourteen months' duration. Cultures made from ear.

Direct smear.—*M. lepræ* in small numbers, averaging about two per oil-immersion field. Majority are single, with very occasional clumps of four to eight members. Bacilli stain brightly.

Case 11—Jose Cabie.

Age 17. Male. Single. Filipino. Occupation, farmer. Family history for leprosy reveals a leprous mother and brother. First sign and symptom were redness on cheek and thickening of ears ten years ago. Received antileprotic treatment, and several injections, several years ago. Physical condition good. Local lesions are extensive macules and nodules over face, ears, arms, and entire body, with ulcerations on legs. Slight enlargement of ulnar nerve. Atrophy of digits.

Summary.—Moderately advanced cutaneous and advanced neural leprosy of ten years' duration. Cultures made from ear, with tissue and blood scrapings.

Direct smear.—*M. lepræ* in moderate numbers, averaging about twenty per oil-immersion field. Majority are in loose or tight clumps of twenty-five to fifty members. Acid fasts stain brightly.

Case 12—Valeriano Cabie.

Age 18. Male. Single. Filipino. Occupation, farmer. Family history for leprosy reveals a leprous mother and brother. First sign and symptom were reddish areas on face and body twelve years ago. Received antileprotic treatment for one month three months ago. Physical condition good. Local lesions are extensive; macules and nodules over face, ears, arms, and entire body, with ulcers on legs.

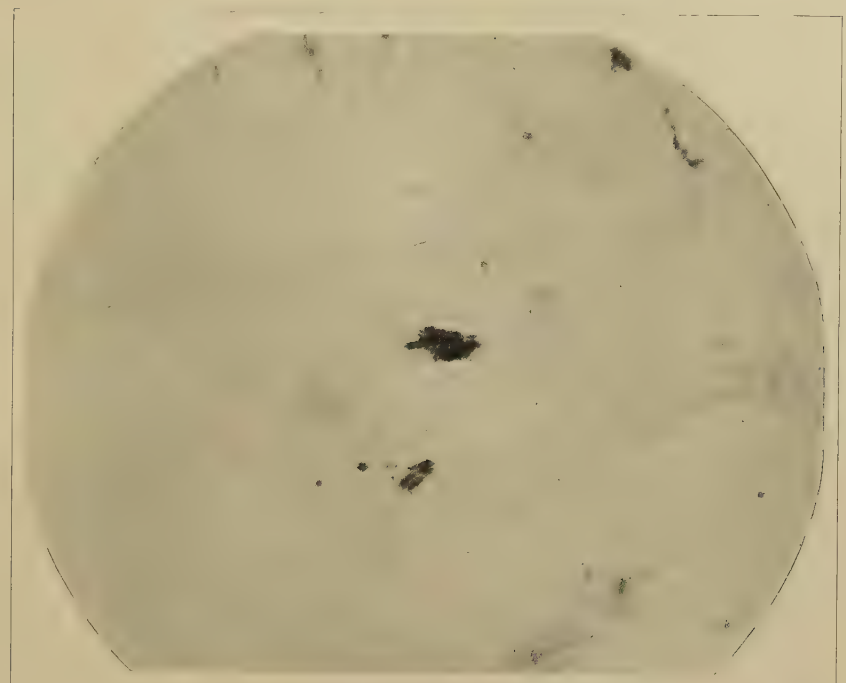
Summary.—Advanced cutaneous and neural leprosy of twelve years' duration. Cultures made from ear, with tissue and blood scrapings.

Direct smear.—M. lepræ in very large numbers, averaging about one hundred per oil-immersion field. Majority are single, but there are many loose clumps of eight to sixteen members, and tight clumps of twenty to fifty members. Acid fasts stain brightly.

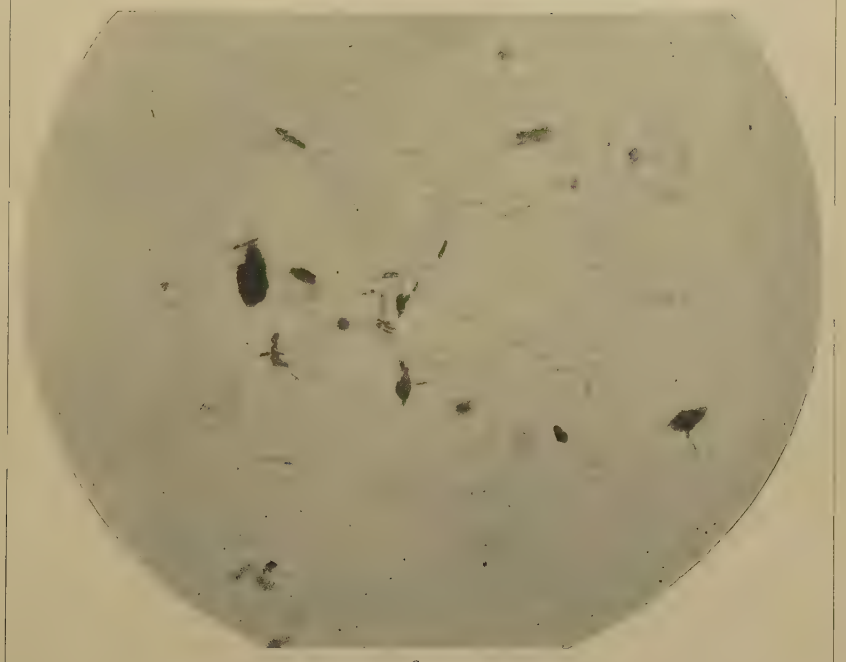
ILLUSTRATION

PLATE 1

FIGS. 1 and 2. Smear from a 158-day growth of *Mycobacterium lepræ*.



1



2

PLATE 1.

SOMATIC SEGREGATION IN DOUBLE HIBISCUS AND ITS INHERITANCE [1]

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THREE PLATES AND ONE TEXT FIGURE

INTRODUCTION

The study of somatic segregation is important genetically for at least two reasons. One reason is that many horticultural varieties of plants have their origin in that type of somatic segregation which is called bud mutation. A second reason is that a somatic segregation may or may not be sexually heritable; hence offering no little difficulty to a geneticist who is studying the inheritance in crosses in which one of the parents or the two used arises as bud sports. An example may help in explaining this point. I have in my plant collection a variety of cassava (*Manihot utilissima* Pohl) which is highly ornamental because the area comprising the center and base of the lobes of its leaf is yellow when the leaf is young and white when it is old. This variety came from a bud sport of another cassava which like most plants of *Manihot utilissima* has solid-green leaves. I have grown about a hundred seedlings of this ornamental cassava and every one of them has solid-green leaves. Knowing its vegetative origin it is of course easy to understand why the ornamental character is not heritable sexually. But let us suppose that we did not know its origin and that this ornamental variety had been crossed for purposes of Mendelian study with a variety with solid-green leaves. The results of such a cross would be highly confusing for we would be looking in the F_2 offspring for a character which would not be there. A confusion arising in this way might be avoided by a study of selfed seedlings of the parents used in crossing, but this is only possible

[1] Experiment Station contribution No. 750. Read before the Los Baños Biological Club February 26, 1931. Received for publication June 17, 1931.

in case of varieties that are self-fertile and self-compatible. If they happen to be self-sterile and self-incompatible then only a knowledge of their vegetative parentage could aid a geneticist in explaining the confusing results obtained in hybridization work involving such somatic segregation.

OBJECT OF THE PRESENT WORK

The object of this paper is to report three types of somatic segregation that have occurred in "double" varieties of *Hibiscus rosa-sinensis* Linnæus and the results of crosses made involving flowers from these somatic segregates.

REVIEW OF LITERATURE

As early as 1913 Wilcox and Holt (1913) reported somatic segregation in flowers of double hibiscus. They reported that "on the Double Salmon there are occasionally dark red double flowers, and the Double Yellow now and then bears a regular double flower half yellow and half salmon, or occasionally flowers which are of salmon color throughout."

The first published report on somatic segregation in *Hibiscus* in the Philippines was made by Mendiola and Capinpin in 1923. They then reported a case of a bud sport consisting of a branch of a pink variety of *H. rosa-sinensis* producing white flowers; and another case of a branch of a red variety producing pink flowers. They also reported cases of plants with entire leaves producing lobed leaves usually at the base of the plant. This case of dimorphism was subsequently studied by the senior author and in a paper published in 1926 he reported that such presence or absence of lobing in the leaves occurred at the juvenile stage of a plant arising either as a seedling or as a cutting and that the presence of lobes in juvenile leaves of *Hibiscus rosa-sinensis* is a simple dominant over absence of lobes.

While I was in Java in 1927, I received a letter from Dr. Jean Schweizer, botanist of the Besoekishch Experiment Station in that country, calling my attention to the occurrence in his garden of a bud variation in *Hibiscus* consisting of a simple red flower which had been produced by a plant of the Double Salmon variety. Doctor Schweizer described the simple flower as in no way different from the common hedge *Hibiscus*. By the common hedge *Hibiscus* I refer to the variety that is common in the Philippines, which I have been calling Native Red Single.

TIME AND PLACE OF THE WORK

The work here reported which covered a period of more than one year, was started December 30, 1929, and the experiments were performed both in the author's plant-breeding garden and in the plant-breeding nursery of the College of Agriculture, Los Baños, Laguna.

OBSERVATIONS AND EXPERIMENTS

CASES OF VEGETATIVE SEGREGATION OBSERVED

A periclinal chimera in a flower of the Double Salmon.—A case was found in which a Double Salmon plant produced a flower which was similar to that of a Double Red except that a number of the petals in the center of the flower remained salmon in color. This would appear to be a case of a periclinal chimera and suggests that the Double Red might have originated as a bud sport of the Double Salmon. The flower showing the chimera was not used in any pollination work as it was severed from the plant when it was given to the author by Professor Herbert, formerly of our Plant Physiology Department.

A bud sport consisting of Double Carmine produced by Double Rose.—If one examines a flower of a Double Rose hibiscus he finds that its "eye" is carmine in color. It apears that through some somatic change during the early history of a bud, a branch can arise which produces flowers all carmine in color instead of being rose with a carmine eye. Such a branch has been produced, and by its propagation by cuttings it has made possible the existence of the variety which we call Double Carmine.

It is quite possible that the first case is a manifestation of the same phenomenon as the second except that in the former, for some reason, the segregation was not completed.

Simple flowers from double varieties.—The production of a simple flower by a double variety has been observed on one branch of a plant of the Double Carmine (see Plate 1) and four branches of a plant of the Double Rose. Two simple flowers were produced by the Double Carmine plant; one was produced December 30, 1929, and the other January 5, 1930. One branch of the Double Rose produced one single flower, in August, 1930. Two other branches, January 29, 1931, produced simple flowers. One of these branches produced one simple flower, and the other branch produced one simple flower and one flower with two whorls of five petals each. These three flowers were excep-

FIG. 1. A periclinal chimera shown by a flower of the Double Salmon hibiscus.

tionally large, measuring 17 centimeters across with pistil about 9 centimeters long. The simple flowers produced by the double varieties were used in pollination experiments which are described later in this paper. For convenience, the simple flowers from Double Carmine are henceforth called Mutant Simple Carmine and those from Double Rose, Mutant Simple Rose.

EXPERIMENTS

Self-pollination.—The two single flowers produced by the Double Carmine were self-pollinated the days they were produced to determine if they were self-compatible and to find out if and how simpleness occurring as a bud segregation in a double variety as well as the carmine color arising from a rose variety with carmine eye were heritable. The same thing was done with the two simple flowers and with the flower with two rows of petals produced by the Double Rose January 29, 1931.

Cross-pollination.—Besides self-pollinating the simple flowers produced by the Double Carmine, they were crossed with nine simple varieties using the former as the source of pollen. The amount of pollen, coming as it did from only two flowers, was quite limited and it was not possible to use as female more than

a total of eighteen flowers of the nine simple varieties mentioned.

The two single flowers produced by Double Rose January 29, 1931 were used as male and crossed with fifteen flowers of seven single varieties.

RESULTS OF EXPERIMENTS

Of self-pollination.—The simple flowers produced by the Double Carmine and the Double Rose failed to ripen pods upon self-pollination, suggesting the probability of self-incompatibility in this case of somatic segregation.

Of cross-pollination.—Of the nine different crosses made between the Mutant Simple Carmine and Single varieties, involving eighteen flowers on the female side, only one succeeded; namely, that with the variety 19–Pink 12396–104. The results of cross-pollination between the Mutant Simple Rose and other varieties are not reported in this work.

The hybrids obtained.—From the successful cross eight plants were obtained. They were given pedigree Nos. 5333, 5334, etc., up to 5340 (see Plate 2). Table 1 gives a brief description of the hybrids. Hybrid 5340 is shown in Plate 3, fig. 1, and hybrid 5333, in Plate 3, fig. 2. It will be noted in Table 1 that of the eight hybrids produced, four turned out to be double and four, single, suggesting a 1:1 ratio and the heterozygosity of one of the parents. While no two of these eight hybrids are exactly alike and none of them is exactly like any other existing variety, most of them are not enough different to warrant their being considered novelties. However, the case is different with No. 5339, which has light French vermilion corollas. As there is no known vermilion double hibiscus, this hybrid, which we will now call Double Vermilion, constitutes an entirely new horticultural variety.

It may be of interest to note here certain habits of some of the hybrids. Let us take No. 5333. This hybrid has a habit which may be called telescopic production of two successive flowers on one peduncle. About ten days after a flower is produced normally on one flower stem, instead of the evidently empty pod falling off, another flower bud begins to come out of it. The bud develops and opens slowly for about twenty days, then it falls off—the flower never opens completely. The second flower is completely sterile, and the normal is fertile in both sexes. A plant with a similar habit was reported by Wilcox and Holt (1913).

TABLE 1.—*Description of hybrids between simple flowers of Double Carmine and a simple variety, 19–Pink 12396–104, and of the parents.*

	Double Carmine.	Simple flowers from Double Carmine.	19–Pink 12396–104.	Hybrid No.—		
				5333	5334	5335
Corolla	Multiple	Single	Single	Multiple	Single	Single.
Color of corolla	Carmine	Carmine	Yellow	Light French vermilion.	Yellow	Light vermilion.
Color of eye	Carmine	Carmine	No eye	Dark carmine.	No eye	Carmine.

	Hybrid No.—				
	5336	5337	5338	5339	5340
Corolla	Single	Multiple	Multiple	Single	Multiple.
Color of corolla	Light orange with vermilion veins.	Carmine	Carmine	Light French vermilion.	Rose.
Color of eye	Carmine	Dark carmine		Dark carmine	Carmine.

Hybrid 5338 produces flowers which either never open completely or open only after about two weeks from the time the petals begin to appear. As in the case of the telescopic flower of No. 5333 the flowers of No. 5338 stay on the stem for a long time. The persistence of the flower on the stem and the inability to open completely appear to be correlated in the case of these two hybrids. What significance this correlation may have as a general biological phenomenon arouses our curiosity.

DISCUSSION OF RESULTS

Because of the accidental nature of the somatic segregation reported and used in this work and the very limited number of flowers which could be used in the pollination experiments and the consequent small number of hybrids which could be obtained, the results presented in this paper necessarily do not have the reliability which more ample data possess. However, as the accident might not happen again for many years or might never happen again, it seems excusable to report these results at this time. Besides, limited though their source is, they nevertheless suggest a number of interesting biological conclusions.

Origin of doubleness and of double varieties.—The term doubleness when used to describe a flower refers to the number of its corollas, and means either two corollas or more than two. The corollas may be arranged as concentric whorls or each may occur with its own center and outside the other. Considering the kinds of vegetative segregation reported in this paper, it may be considered as certain that some of our double varieties are color segregates of other double kinds, while some of our simple varieties arose as bud sports of others which bear multiple corollas. It is interesting to note here that in the case of *Hibiscus syriacus* Linnæus the Double and Simple white varieties are similar in practically all respects, except that one produces double flowers and the other simple flowers. The same is true with the Double Lilac and Simple Lilac. Furthermore, the white varieties are similar to the lilac, except in color. All of these similarities suggest common vegetative parentage for all these four varieties of *H. syriacus,* sexual parentage being highly improbable as none of them is self-fertile.

When we attempt to explain the origin of doubleness in *Hibiscus* we find ourselves treading on more theoretical grounds. The habit already cited of hybrid 5333, of bearing two successive flowers on one flower stem seems to me to betray the secret of the origin of doubleness. Hybrid 5333 is a very prolific flower bearer. These two characteristics of No. 5333 suggest that doubleness has its origin in heterosis, or hybrid vigor. It is possible that natural crossing between two previously existing simple varieties produced hybrid vigor in the hybrid. The hybrid vigor resulted in the capacity of the hybrid to produce a much greater number of flowers than either one of its parents. Some of these flowers are produced simultaneously on one flower stem, resulting in doubleness. Sometimes a flower is produced much earlier, resulting in the production of a simple vegetative segregate on a double variety or sometimes the flowers coming out on one stem are produced successively, resulting in the telescopic appearance as exhibited by hybrid 5333.

Appearance of rose color of petals in a cross between carmine and yellow.—It will be recalled that the hybrids reported in this experiment are F_1 progeny of a cross between a variety with carmine petals and another with yellow petals. Among these hybrids is one, No. 5340, that produces rose petals. The appearance of the rose color may best be explained by recalling that the carmine parent arose as a bud sport of a rose plant.

It seems probable that the carmine sport, while carmine phenotypically, retains a determiner for rose color which reappears when conditions become favorable.

Because of the small number of hybrids raised, it is not advisable to consider the results of the cross statistically. It may be pointed out, however, that according to the assumption made above, there should result a greater number of carmine individuals than either yellow or rose, and this is exactly what happened, as shown by Table 1.

Before concluding the discussion of the appearance of rose in a cross between carmine and yellow, it is well to point out again that a knowledge of the vegetative origin of a variety is bound to prevent us from adopting a wrong explanation of the unexpected appearance of a character among hybrids. Taking as an example the appearance of rose in a cross between carmine and yellow already described, it is quite likely that had we not known that the carmine parent arose from a rose variety, we would be explaining the appearance of the rose color on the basis of complementary factors, an explanation that is not the best at all to offer at the present time.

Simple on double not involving mutation of a factor.—It has been pointed out that the hybrids reported in this paper constitute the first filial generation of a cross between a simple flower produced on a branch of a double variety and another simple flower of a simple variety. The fact that nearly half of the hybrids turned out to be double shows that the appearance of the simple flower on a branch of a double variety was not due to a mutation of a factor for doubleness into that for singleness, this conclusion being supported by the additional evidence that the branch that once produced the simple flower continues to produce double flowers.

Inheritance of doubleness.—Table 1 shows that of the eight hybrids obtained four were single and four were double, suggesting that one of the parents was homozygous and the other heterozygous. In the past I have performed numerous crosses between simples and as no doubles have been produced this way it may be concluded that simpleness is a homozygous recessive while doubleness is a heterozygous dominant. *Dd* may represent doubleness and *dd* simpleness. $Dd \times dd$ will result in $2Dd : 2dd$, or 50 per cent double and 50 per cent single. The somatic segregation of a single flower from a double may be explained by *D* of *Dd* changing to *d*.

Inheritance of the somatic segregate carmine.—In all the crosses which we have made in the past between rose and yellow, no carmine ever appeared among the hybrids. Furthermore, selfings made of either rose or yellow never produced carmine. These facts indicate that in the carmine hybrids produced in the cross Mutant Simple Carmine × 19 Pink 12396–104, which cross may for convenience be stated as *carmine* × *yellow*, the carmine was due to the mutant carmine and not to any recessive carmine combined with the pink of the original rose parent of the carmine segregate. These facts also prove that while carmine appeared as a somatic segregation, the change affected the germplasm with the result that it became heritable sexually.

SUMMARY

1. This paper reports three cases of somatic segregation found in double varieties of *Hibiscus rosa-sinensis* Linnæus in the Philippines; namely, (*a*) a periclinal chimera in a flower of the Double Salmon, (*b*) a branch of a Double Rose producing double carmine flowers and serving as the origin of our Double Carmine variety, (*c*) single flowers being produced by branches of Double Rose and Double Carmine varieties.

2. Through the production of the simple flowers by the Double Carmine variety, it was possible to cross this with a simple yellow variety. Among the hybrids produced by this (double carmine × simple yellow) cross there was a carmine plant and a rose individual, showing that while the carmine sport is carmine phenotypically, it retains the rose determiner.

3. The carmine somatic segregate was found to be sexually heritable.

4. The somatic segregation consisting in the production of simple flowers by a double branch does not seem to have involved the mutation of a factor.

5. Attention has been called to the fact that a somatic segregation which does not affect the germplasm and is not, therefore, sexually heritable is likely to confuse the results of a given cross in which one of the parents is a variety that has originated as one such vegetative segregate. It is quite likely that the failure of a character of a given parent to appear in any of its hybrid offspring may be traced to this cause. This makes it important that we know the vegetative origin of our horticultural varieties or clons.

LITERATURE CITED

MENDIOLA, N. B., and J. M. CAPINPIN. Breeding ornamental hibiscus. Philip. Agr. 11 (1923) 217–230.

MENDIOLA, N. B. A Manual of Plant Breeding for the Tropics. University of the Philippines, Manila (1926) XXIII + 360 with text figures and plates.

WILCOX, E. F., and V. S. HOLT. Ornamental hibiscus in Hawaii. Hawaii Agr. Exp. Sta. Bull. 29 (1913).

ILLUSTRATIONS

PLATE 1

A Double Rose hibiscus plant showing in the left circle a normal double flower and in the right circle the simple flower which arose as a vegetative segregate.

PLATE 2

Hibiscus (19 Pink–12396–104 × Mutant Simple Carmine) F_1.

PLATE 3

FIG. 1. Hibiscus hybrid 5340, showing its double flower.
2. Hibiscus hybrid 5333, showing its double flower.

TEXT FIGURE

FIG. 1. A periclinal chimera shown by a flower of the Double Salmon hibiscus.

PLATE 1.

PLATE 2.

1 2

PLATE 3.

DAYTIME RESTING PLACES OF ANOPHELES MOSQUITOES IN THE PHILIPPINES

FIRST REPORT [1]

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FOUR PLATES

INTRODUCTION

Referring to the resting places of anophelines, Boyd(1*a*) in his very useful textbook on malariology summarizes as follows the places where one should look for the adults of *Anopheles* in the daytime:

1. Inside houses, especially the sleeping rooms, the darker corners, the ceiling, the wall behind furniture and pictures, dark clothing, or underneath furniture.
2. Underneath buildings. On leeward side of chimney bases and on windward side of joists.
3. In stables, pigsties, chicken houses, kennels, hutches, etc. when occupied.
4. In porches and verandas.
5. In privies.
6. Under bridges and in culverts.
7. On the shady side of road-cuts, stream and ditch margins having precipitous banks; in open wells, under ledges, and in caves.
8. On weed grown piles of brickbats and stones.
9. In the interior of hollow trees, or in the spaces between buttressing roots.
10. On the underside of leaves in dense thickets, or in clumps of shrubs and annual plants, perhaps in clumps of high grasses as well.
11. In cracks in the ground.

Hehir(2) referring to the adult anophelines of India, writes as follows:

Out-houses, bath-rooms, damp go-downs, shaded verandahs, cow-sheds, coach houses, garages, stables, unoccupied thatched houses, with dirty

[1] The International Health Division of the Rockefeller Foundation, of which the author is a field director, is coöperating with the Bureau of Science of the Philippines in malaria investigations. Mr. Domingo Santiago, field inspector of malaria investigations, made the routine catches reported in the tables.

soot-covered walls, are special day resorts for anophelines. In a native village or bazaar select huts that are near a pond, water channel or other breeding place of mosquitoes. Some favour the thatch beneath the eaves of huts and houses and require a ladder to reach them. Anophelines are rarely seen on whitewashed walls in the daytime and seldom at night. They may often be found in holes in walls, or in the corners of rooms, under beds and tables, in cupboards, on dark clothes in rooms; behind pictures, doors, furniture, in open fire-places and chimneys, in lavatories; under porches and in sheds, under bridges and culverts, in wells and unscreened cisterns; they are fond of hiding in old boots (Wellingtons and polo boots especially), on saddles—leather seems to attract them. We may see them at night wandering about the shady side of the mosquito net. The wooden rafters of thatched houses are a favourite retreat. In such shady places they are readily captured as they are probably asleep, and it is usually easy to place the butterfly net or mouth of the test-tube quickly and quietly over them. The distribution of some species of Anopheles is very local, hence it is necessary to examine as many likely places as possible.

From these descriptions one might imagine that it is never a difficult matter to find adult anophelines in the daytime in localities where abundant breeding is known to exist. But as a matter of fact malaria surveys in the Tropics have frequently in the past been handicapped because adult *Anopheles* mosquitoes, especially of the species carrying malaria, could not be captured in their daytime resting places. These shelters have often defied careful search by skilled field inspectors.

Boyd(1*b*) refers to this fact and comments that Oriental anophelines appear to be much less inclined to linger about dwellings than do their relatives elsewhere.

MacGregor(3) in his excellent manual for mosquito surveys cautions that it is well to note that certain species of anophelines which enter houses to bite the inhabitants rarely remain in the house after they have fed. They always attempt to get out of doors immediately after feeding. Consequently, the presence of these species is not to be detected by a daytime search.

Hackett,(4) who has had wide experience with anophelines in various parts of the world, wrote after a visit to the Orient, as follows:

> I had no idea until I visited the Far East how difficult it is to lay hands on the adults of most of the principal malaria carriers.

LITERATURE

Without attempting an exhaustive survey of the literature several references may be cited as of interest in connection with this subject. These make it obvious that uniformity of results

has not been the rule. In India, for example, it has not always been a difficult matter to make daytime catches of adult anopheline mosquitoes. Refer again to Hehir.(2) Also note a report by Christophers(5) of some malaria surveys in 1925. In this report Christophers writes as follows:

> Anopheles in the houses at the time of my visit, though no longer very numerous, were to be obtained without great difficulty . . . Adult anopheles at Manharpur were fairly abundant in cow-sheds, etc., at the Babus' old quarters.

Other Indian references could be cited which indicate that adult *Anopheles* have been caught in daytime resting places in the course of malaria surveys; but there have been real difficulties, for Christophers, Sinton, and Covell,(6) in their guide for malaria surveys, comment as follows:

> If catches of adults made in the houses are carefully and critically examined in relation to the breeding places, and other catches of adults made in the open, a very great deal may be learnt about the behavior of Anophelines in particular circumstances. This work however has seldom been attempted and there is consequently a large field for enquiry on such lines.

In Ceylon only recently have daytime searches for adult *Anopheles* been successful. For example, James and Gunasekara(7) reported that adult anophelines were scarce and difficult to find. Barnes and Russell(8) wrote, "It has generally proved difficult to find the resting places of anopheles mosquitoes within village houses." Carter(9) in his very complete report on malaria and anopheline mosquitoes in Ceylon wrote:

> Adult *Anopheles* were not always abundant even although the time chosen for the visit appeared suitable, and on several occasions considerable difficulty was experienced in obtaining what were relatively small numbers.

It was therefore notable when Carter and Jacocks(10,11) by paying particular attention to the matter were able to find between 9 a. m. and 4 p. m. considerable numbers of *Anopheles* resting on walls and hangings of village huts, small bungalows, and coolie barracks in various localities in Ceylon. As a result they were able to prove the importance of *A. culicifacies* as a malaria carrier in Ceylon by actual sporozoite findings in wild-caught specimens, something which had never been done conclusively before. Plate 1, fig. 1, shows the type of coolie barracks in which *A. culicifacies* were caught in the daytime, as demonstrated to me in November, 1929.

In British Malaya, while there have been reports of daytime catches of *Anopheles* mosquitoes, not many records are to be found. In the 1919 report of the Malaria Bureau(12*a*) there is reference to 15 adults caught in thirteen days search at Perhentian Tinggi. In the 1922 report (12*b*) it is noted that 10,327 adults had been caught in houses but apparently none were *A. maculatus*, the chief malaria-carrying species. In the 1923 report(12*c*) there is a record of 342 adult mosquitoes caught on a Johore estate in the houses. Of these 335 were *A. maculatus* and 11.5 per cent of the 199 dissected were found to be infected.

From personal experience in the Straits Settlements and in Kedah, I know that it is difficult to find adult *A. maculatus* in daytime resting places. In typical Malay houses they are seldom to be found, and they do not rest under such houses. In the darker and damper coolie barracks, or lines, they are more apt to be found, but even here the catch of anophelines seldom includes *A. maculatus*.

From the Dutch East Indies have also come reports both of good catches of adult mosquitoes and of meager results. Van Breemen(13) reported catching large numbers of *A. ludlowi* inside houses. In one locality adults were regularly caught, although larvæ could not be found. Swellengrebel and others(14) had no difficulty in catching *A. ludlowi* adults but speak of "many other species which leave the house shortly after feeding or which do not feed within the house. These species should be caught in the daytime on plants or trees or under the house or in the evening on man, cows or principally on buffaloes . . . catching on buffaloes is a precious method to collect species not to (be) found in houses." Schuffner and others(15) had the same experience and point out that *A. ludlowi* "is not found in empty houses." These authors(15) speak of other anophelines which after feeding "fly away again and hide themselves in trees, shrubs, ditches or other cavities."

But even *A. ludlowi* has not infrequently been elusive. Brug and Walch(16) in Solo reported, for example, that "five coolies under the supervision of a sanitary inspector could not catch more than 6 anopheles in a kampong such as Tjinderedjo, where at that time the parasite index of the children was 90, that for the adults 65." The authors(16) themselves had no success although they examined "dark corners and holes" and "crept under bedsteads." They finally succeeded in catching *Anopheles*

adults at night on buffaloes, although they had to offer a premium for the catches.

Again in Tegal, Walch and Soesilo(17) had to offer premiums for adult anopheline catches which, although in one case averaging forty-six, usually averaged less than two per catch.

Schuurman and Bokkel Huinink(18) on the south coast of Java caught fair numbers of anopheles adults "in and in the neighbourhood of the houses."

Essed(19) in reporting from Banjoewangi, Java east coast, comments that "if these hiding places such as mosquito-nets and dark recesses behind beds are not present, then one can seek in vain in the native and other houses for Anopheles."

As to the western tropics the situation is the same as in the East as regards catching adult anophelines. Some have reported good catches. For example, Le Prince and Orenstein(20) wrote of their experience in Panama as follows:

> While no suitable hiding places except vacant houses were without mosquitoes in the daytime, yet beyond the settled area none were found. . . . Large numbers were collected under houses where the breeze was sufficiently strong to make the lighting of a match difficult. These inhabited houses were on posts from two to ten feet above the ground. The dry weather ground-cracks under the houses were several inches deep and the mosquitoes collected in them.

On the other hand Boyd and Aris(21) wrote of their Jamaican experiences as follows:

> Searches made within houses during the day rarely yielded imagines, even though large numbers could be caught at night in the vicinity from a horse or mule as bait.

Stephens(22) in reporting a survey on a Venezuelan oil field wrote as follows:

> The search for anophelines in the native huts in the daytime was completely fruitless, and culicines also were very scanty. This condition was in marked contrast to those observed by me in the neighborhood of Lake Valencia, which I visited on my way home, where in the daytime, in the verandah of a hut it was easy to collect numerous anophelines, embracing three different species.

In Porto Rico Earle(23) relies not on routine daytime catches but on traps baited at night with such animals as calves or horses. He has been very successful with these traps. This is true also of Manalang(23, 24) in the Philippines.

THE PHILIPPINES

In the Philippines as elsewhere in the Orient it is not an easy matter to make routine daytime catches of anopheline adult mosquitoes. Refer again to Hackett(4) who wrote:

> In the seven days I spent in the [Philippine] Islands I did not catch a single one [*A. minimus*] although a sporting colleague offered as high as a peso [50 cents gold] apiece for adult specimens. At the same time the larvae were abundant.

Manalang, who has made extensive and notable studies on *A. minimus* (*A. funestus*) in the Philippines, writes:(25) "The adult mosquito is typically 'wild' in that it is very seldom found in the ordinary nipa house at night, much less in the day time." The reason may sometimes be as suggested by Walker and Barber(26) that it is the custom of the people in the rural districts to wash clothes and bathe in the streams, often in the early morning or evening, thus affording ample opportunity to the forest-loving anophelines. These observers,(26) however, made fair daytime catches of adult mosquitoes in houses in Mindoro and at Iwahig. In the latter place, a penal colony, the catches were chiefly inside mosquito nets which had been badly adjusted. They found only a few imagines along the banks of streams or in crab holes. They suggested in their report(26) that certain meteorological conditions influence the dispersal of adults. Their negative results were in localities having at the time hot and dry weather.

There have been no records of routine daytime catches of adult *Anopheles* in the Philippines. Where these adults, particularly *A. minimus* adults, go in the daytime has been and still is a question. This paper gives some information, but much more investigation along this line is required.

The typical Filipino nipa house in rural areas is built high off the ground. It is light, airy, and dry. It contains as a rule very little furniture and no beds. Roofs may be either of tin or thatching (Plate 1, fig. 2). At first glance it would seem as though *Anopheles* mosquitoes would find ideal sheltering places under such houses. In the Southern United States it has been my experience, common to that of many others, that where breeding is abundant it is more usual than not to find adults of *A. quadrimaculatus*, the malaria carrier, under houses resting on the sides of beams. In repeated searches in the Tropics I have so far always failed to find mosquitoes in such places.

Furthermore, *Anopheles* mosquitoes are rarely to be found inside such houses in the Philippines.

ROUTINE COLLECTIONS

During the last quarter of 1930 routine weekly catches were attempted not only in certain houses (as shown in Table 1) but also on the sides of a well (Table 2), along a stream bank (Table 3), and in the cracks of a stone wall (Table 4). These catching stations were all in or near Calauan, Laguna Province, Luzon Island.

TABLE 1.—*Adult Anopheles mosquitoes caught inside houses during routine weekly collections October to December, 1930, Calauan. Only nighttime catches are shown as no Anopheles mosquitoes were caught inside houses by day. No traps used.*

Species.	Sex.		Total.
	Male.	Female.	
Anopheles subpictus (fresh water)	2	3	5
Anopheles vagus (Philippine forms)	3	5	8
Total	5	8	13

TABLE 2.—*Adult Anopheles mosquitoes caught on the sides of an open well, Masiit, October to December, 1930, in routine weekly collections.*

[Catching time about ten minutes once a week.]

Species.	Sex.		Total.
	Male.	Female.	
Anopheles kochi (Donitz 1901)	4	8	12
Anopheles tessellatus (Theobald 1901)	36	56	92
Total	40	64	104

The well used as a catching station is of the surface type having no protection around the top except long grasses and low bushes. The water level is about 7 feet below the ground surface and the well is about 15 feet deep. The sides of the well are of earth, and there are places where the top overhangs miniature caves in which adult mosquitoes are apt to be found among exposed roots. Here it is darker, damper, and more protected. The water of the well is not much used, and *A. tessellatus* is breeding in it (see Plate 3, fig. 3, and Table 2).

TABLE 3.—*Adult Anopheles mosquitoes caught along a stream bank, Masiit, October to December, 1930, in routine weekly collections.*

[Catching time about thirty minutes once a week.]

Species.	Sex.		Total.
	Male.	Female.	
Anopheles bancrofti var. *pseudobarbirostris* (Ludlow 1902)	3	3	6
Anopheles barbirostris (van der Wulp 1884)	6	7	13
Anopheles fuliginosus (Giles 1900)	1	3	4
Anopheles kochi (Donitz 1901)	4	8	12
Anopheles minimus (Theobald 1901)	126	272	398
Anopheles tessellatus (Theobald 1901)	36	56	92
Anopheles vagus (Philippine form)	52	93	145
Total	228	442	670

TABLE 4.—*Adult Anopheles mosquitoes caught along an old stone wall, Calauan, October to December, 1930 in routine weekly collections.*

[Catching time about fifteen minutes once a week.]

Species.	Sex.		Total.
	Male.	Female.	
Anopheles barbirostris (van der Wulp 1884)	2	1	3
Anopheles hyrcanus var. *sinensis* (Wiedeman 1828)	0	1	1
Anopheles kochi (Donitz 1901)	3	9	12
Anopheles minimus (Theobald 1901)	6	9	15
Anopheles philippinensis (Ludlow 1902)	1	0	1
Anopheles tessellatus (Theobald 1901)	2	26	28
Anopheles vagus (Philippine form)	75	64	139
Total	89	110	199

In Plate 2 is shown the stream along which catches of adult *Anopheles* were made. It is a typical *A. minimus* breeding place of the Philippines. Plate 3, fig. 2, shows a catching station. Here the stream bank is eroded and is overhung by vegetation, so that a darkened, damp, and sheltered resting place is formed (see Table 3).

Another resting place for adult anophelines in the Philippines is shown in Plate 4, figs. 1 and 2. This stone wall is in an old cemetery about 1 kilometer from the nearest mosquito breeding places. The wall is well shaded by high bushes, vines, and trees. There are numerous large cracks and crevices in which mosquitoes find darkened, sheltered resting places which are, however, not very damp, in fact they seemed distinctly dry.

From these findings it appears that routine daytime catches of *Anopheles* imagines in the Philippines will have to include not only human habitations or animal houses, but primarily natural shelters such as cracks, crevices, and caves near or in the ground, not necessarily near breeding places. Further searching in different types of houses and with nets among grasses and bushes may reveal other sheltering places, but at the present time, for the rural Philippines, the records in the tables of this report may be taken as indicating the preferences of adult *Anopheles* for their daytime resting places. For the catching of *Anopheles* imagines in the Tropics trapping would seem to be the most effective method, although traps still leave much to be desired.

SUMMARY

A brief review of the problem of catching adult *Anopheles* mosquitoes in their daytime resting places in the Tropics is presented. Some observations are given as to the situation in the Philippines.

REFERENCES

1. Boyd, M. F. An Introduction to Malariology. Harvard University Press, 1930. (*a*) Page 313. (*b*) Page 314.
2. Hehir, Sir Patrick. Malaria In India. Oxford University Press (1927) 62.
3. MacGregor, M. E. Mosquito Surveys. Wellcome Bureau of Scientific Research, London (1927) 235.
4. Hackett, L. W. Differences in the habits of anophelines which transmit malaria in America, in Europe, and in the Far East. Southern Med. Journ. 22, No. 4 (April, 1929).
5. Christophers, S. R. Two malarial surveys connected with industrial projects in certain very highly malarious localities in India. Indian Journ. Med. Res. 23, No. 2 (October, 1925) 355, 389–391.
6. Christophers, S. R., J. A. Sinton, and G. Covell. How to do a malaria survey. Health Bull. 14. Malaria Bureau No. 6. Govt. of India, Central Publication Branch (1928) 53.
7. James, S. P., and S. T. Gunasekara. Report on malaria at the Port of Talaimannar. Sessional paper 34 (1913). Govt. Printer, Colombo, Ceylon.
8. Barnes, M. E., and P. F. Russell. A programme for the control of malaria in Ceylon. Sessional paper 9 (1926). Govt. Printer, Colombo, Ceylon.
9. Carter, H. F. Report on malaria and anopheline mosquitoes in Ceylon. Sessional Paper 7 (1927). Govt. Printer, Colombo, Ceylon.
10. Carter, H. F., and W. P. Jacocks. Observations on the transmission of malaria by anopheline mosquitoes in Ceylon. Ceylon Journ. Sci. Sec. D. Med. Sci. 2 (1929) 67–86.

11. CARTER, H. F. Further observations on the transmission of malaria by anopheline mosquitoes in Ceylon. Ceylon Journ. Sci. Sec. D. Med. Sci. 2, No. 4 (1930).
12. Federated Malay States, Malaria Bureau Reports, Kuala Lumpur. (*a*) Vol. 1, Report VI (1919). (*b*) 1922 report, page 1. (*c*) 1923 report.
13. VAN BREEMAN, M. L. Malaria in Weltevreden and Batavia. Med. van der Burg. Geneesk. d. in Ned. Indie, No. 2 (1919).
14. SWELLENGREBEL, N. H., W. SCHÜFFNER, and J. M. H. SWELLENGREBEL DE GRAAF. The susceptibility of anophelines to malaria-infections in Netherlands India. Med. van der. Burg. Geneesk. d. in Ned. Indie, No. 3 (1919).
15. SCHÜFFNER, W., N. H. SWELLENGREBEL, J. M. H. SWELLENGREBEL DE GRAAF, and ACHMAD MOCHTAR. On the biology of M. ludlowi in Sumatra. Med. var den Burg. Geneesk. d. in. Ned. Indie, No. 3 (1919).
16. BRUG, S. L., and E. W. WALCH. Report of an investigation of a malaria epidemic in Solo 1926. Med. van der dienst der Volksgez. in Ned.-Indie (1927).
17. WALCH, E. W., and R. SOESILO. Investigation of a malarial epidemic in Tegal, during the first month of 1926. Med. v. d. dienst d. Volksgz. in Ned. Indie, Part I (1927).
18. SCHUURMAN, C. J., and A. SCHUURMAN-TEN BOKKEL HUININK. A malaria problem on Java's south-coast. Med. v. d. dienst d. Volksgez. in Ned. Ind. (1929).
19. ESSED, W. F. R. Malaria at Banjoewanji and the prospects of an efficient species sanitation. Med. v. d. dienst d. Volksgez. in Ned. Indie (1929).
20. LE PRINCE, J. A., and A. J. ORENSTEIN. Mosquito Control in Panama. G. P. Putnam's Sons, N. Y. (1916) 86.
21. BOYD, M. F., and F. W. ARIS. A malaria survey of the Island of Jamaica, B. W. I. Am. Journ. Trop. Med. 9, No. 5 (1929) 381.
22. STEPHENS, J. W. W. Malaria on a Venezuelan oilfield. Ann. Trop. Med. & Parasit. 15, No. 4 (1921) 439.
23. Personal observation supplemented by personal communication.
24. MANALANG, C. Does the amount of malaria depend on the number of transmitting mosquitoes? Journ. Trop. Med. & Hyg. 34, No. 2 (1931).
25. MANALANG, C. Notes on malaria transmission. Philip. Journ. Sci. 37 (1928).
26. WALKER, E. L., and M. A. BARBER. Malaria in the Philippine Islands. Philip. Journ. Sci. § B 11 (1914).

ILLUSTRATIONS

[Photographs by the author.]

PLATE 1

FIG. 1. Coolie barracks in Ceylon in which adult *Anopheles culicifacies* were regularly caught in the daytime.
2. Typical rural Filipino houses.

PLATE 2

A typical *Anopheles minimus* breeding place in the Philippines.

PLATE 3

FIG. 1. Looking obliquely at the side of a well overhung by roots and grasses. (See Table 2 and the text.)
2. A catching station for adult *Anopheles minimus* mosquitoes.

PLATE 4

FIG. 1. Stone wall in old Calauan cemetery. (Time exposure.)
2. Close view of resting places of *Anopheles* on a stone wall. (Time exposure.)

1

2

PLATE 1.

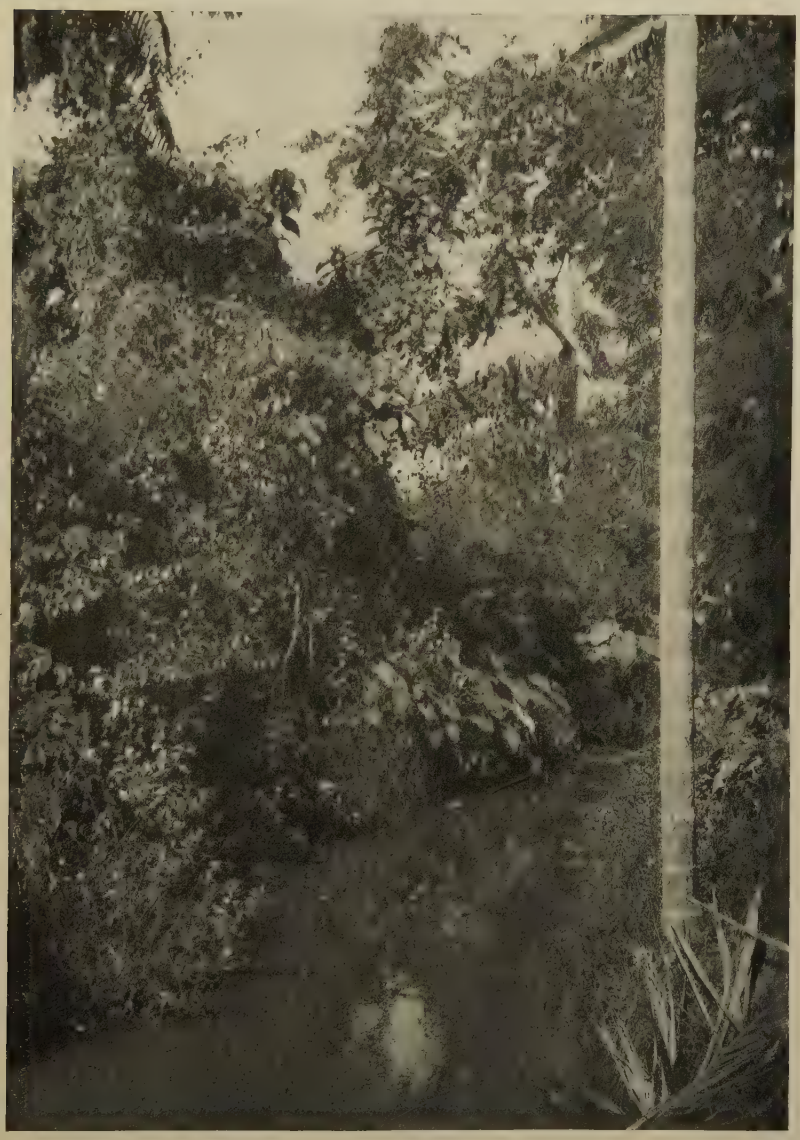

PLATE 2.

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PLATE 3.

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PLATE 4.

AVIAN MALARIA STUDIES, III

THE EXPERIMENTAL EPIDEMIOLOGY OF AVIAN MALARIA; INTRODUCTORY PAPER [1]

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TWO PLATES AND THREE TEXT FIGURES

INTRODUCTION

Although epidemiology as an ancient science dates back to Hippocrates (1) it has had remarkably little experimental study. Prior to Hippocrates epidemics were viewed entirely from a supernatural or metaphysical standpoint. Witness, for example, the Chaldaic *malus annus*, or evil year. In the Hippocratic writings can be seen the first attempts to identify the natural factors causing epidemics. Hippocrates gave little credence to mysterious agents of the superstitious, but a conception of infection was totally lacking, and so explanation of external causes of epidemics, as based on Hippocrates's observation, involved careful consideration of the constitution of the atmosphere, of cosmic influences, and seasons. This modest theory and Galen's suggestive writings as to a distinction between exciting and predisposing causes were unheeded until Guillaume de Baillou (1538–1616), (2) physician to the Dauphin of Henri IV, reintroduced the idea that certain seasons and certain years are by their peculiar innate nature subject to certain diseases. Baillou has been called "the first epidemiologist of modern times."

[1] The first experiment reported in this paper was done in the Department of Tropical Medicine, Harvard University Medical School, through the courtesy of Prof. R. P. Strong and with the assistance of the International Health Division of the Rockefeller Foundation. The second and third experiments were done at the Bureau of Science, Manila, where the author is chief of malaria investigations in which the bureau and the division are coöperating. Misses Amparo Capistrano and Filomena Villacorta, of the staff of malaria investigations, assisted in the blood examinations in the last two experiments. Mrs. Isabel Ramos, also of the staff, assisted in handling the mosquitoes.

Thomas Sydenham (1624–89) expanded this theory of *genius epidemicus*, or *"epidemic constitutions."* Delving into accounts of outbreaks of disease in London over a 25-year period, he attributed great importance to the influence of season and climate, not only in the origin of epidemics but even in determining predominant clinical manifestations of a given disease. Smallpox under one epidemic constitution might be a very different matter as a disease and as an epidemic from smallpox under another constitution.(3, 4, 5, 6)

Since Sydenham's time, except for an incorporation into the concept of epidemic constitutions of the fact of infection by demonstrable pathogenic organisms, there has been surprisingly little progress in the development of the theory of epidemic disease. Even to-day epidemics of malaria, influenza, plague, cholera, and smallpox, for example, are in some phases as mysterious as they were to Hippocrates.

Present belief is in general as stated by Topley: "The origin and spread of any epidemic of microbial infection depends upon variations in the normally existing relations between living organisms; and the actual outbreak of disease, the occurrence of clinically recognisable cases, is only the end-result of a progressive disturbance of this normal equilibrium."(63) This being true, Topley goes on to point out, the problems of epidemic disease thereupon assume an aspect more biological than medical. This last observation is especially true of malaria.

Not to mention the classical and historical methods, there are, as Brownlee(14) states, three ways in which the biological basis of epidemics may be sought. There may be observation of the mode of progress of the epidemic, in the first place, as it occurs in nature or, in the second place, as during an experiment. In the third place there may be an examination of accumulated statistical information at our disposal.

Hippocrates, Baillou, and Sydenham followed the first way. In their footsteps have come Maximillian Stoll (1742–1787), of the old Vienna school; Lancisi (1655–1720), the Italian; and more recently Hamer,(7–10) Crookshank,(11, 12) and many others.

The third way was opened by William Farr (1807–1883), author of a "law" to the effect that "the curve of an epidemic at first ascends rapidly, then slopes slowly to a maximum, to fall more rapidly than it mounted." Greenwood, Brownlee, Ronald Ross, and others have followed Farr and their epidemic curves are usually of the normal bell-shaped Farr type.(13–26)

Ross, in particular,(19–26) ever since his epochal discovery of the transmission of malaria by mosquitoes, has been interested in the mathematics of the spread of malaria. He has applied the theory of probabilities to the statistical prognosis of epidemics, dealing particularly with the statics or equilibrium of malaria. His equations have been carefully analyzed and amplified by Lotka,(27–29) who has dealt more especially with the kinetics of malaria. Others who have dealt with malaria mathematically are Waite(30) and McKendrich.(31, 32) As yet, however, there are no data available for numerical comparison between mathematical formulæ and observed conditions.

The second way of approach to the biological basis of epidemics—the way of direct experimental epidemiology—has only recently been taken. Reports of Löffler,(33) Danysz,(34, 35) Bahr,(36) Liston,(37) Xylander,(38) Mühlens,(39) and Bainbridge(40) were suggestive. The first direct attempt at experimental epidemiology was made by Topley and his colleagues(41–72) in England. They have carried out notable studies with mouse pasteurellosis infections.

These men have studied the epidemiological history of a "little community, wholly exempt from *res angusta domi* in any sense of the phrase, well fed, well housed, with nothing to do but eat, fight, make love, and sleep, shielded from contamination by supermedical officers of health, and most efficient birth control."

They have "brought the doctrine of Epidemic Constitutions within the compass of natural inquiry."(62)

One of their most important findings has been that "a pasteurellosis will continue as a fatal infectious disease within a population of mice replenished wholly by additions of normal animals, not infected prior to immigration, over a period of more than $3\frac{1}{4}$ years, that is through a period longer than a generation."(58) In other words, the admission to a controlled community of mice of individuals not having the disease that is epidemic in that community is a danger to that community. Here then is a suggestive lead for investigation in human herds, for much of our community prophylaxis ignores completely incoming normal persons.

Outstanding and independent work in experimental epidemiology in villages of mice has been done at the Rockefeller Institute by Flexner, Webster, and associates. These studies have shown that epidemics may arise from increased dosages of the patho-

genic organism. There is acceleration or diminution in response to factors that determine the susceptibility or resistance of the population. It appears from this work that the course of events in the epidemics was based on the distribution of the bacterial parasite among the population at risk and the susceptibility of the individuals comprising the population. Bacterial virulence does not appear to have been a changing factor. Later studies at the institute have been with respiratory infections in rabbits and with fowl cholera.(73–123) Neufeld, Lange, and coworkers, at the Robert Koch Institute in Berlin, have also investigated problems of experimental mouse typhoid.(124–133)

Still other attempts to study epidemiology by controlled experiments are those of Perla and Lurie(134–139) with artificially induced epidemics of tuberculosis in rabbits. Koch(140) observed that rabbits and guinea pigs exposed in the same room with tuberculous animals for a longer period than four months not infrequently acquire tuberculosis. Perla and Lurie have attempted well-controlled experiments on the basis of observations from spontaneous outbreaks.

There are many references in the literature to spontaneous epidemics of disease among laboratory animals and these often afford excellent although uncontrolled opportunities for study. As an example the reports of Theobald Smith and Nelson,(141, 142) on paratyphoid in guinea pigs, may be cited.

Such natural episodes cannot, however, take the place of experimentally produced epidemics which, although simulating the usual, are yet unusual in that certain factors are manipulated and controlled in a uniform way.

These references to studies in the experimental epidemiology of bacterial diseases are given not because they shed much light on the spread of malaria in a community of birds. They are cited, with such bibliography as is available to the author, because they illustrate a new method of approach to problems of epidemiology, whether the disease in question be due to bacteria directly passed from individual to individual or due to protozoa carried by an arthropod host. Such experiments inaugurate a new era in epidemiology.

It is undoubtedly open to question whether experimental epidemics within the confines of small cages accurately reflect the phenomena of natural outbreaks of disease, and it is partly to answer this question that the following experiments have been

undertaken. While the immediate findings of the experiments here reported are meager yet the general way of approach may lead into fertile territory.

So far as the author is aware this is the first report to be published on the experimental epidemiology of malaria, based on miniature epizoötics of the disease in laboratory animals. There is a brief reference in Gill's excellent textbook on epidemiology, to some abandoned studies with experimental malaria in sparrows. No other has been found in the available literature.

GENERAL EPIDEMIOLOGY OF MALARIA

Certain fundamental considerations governing the spread of malaria are well known. Before a new case can arise in a community the following conditions must obtain progressively:

1. There must be a gametocyte carrier; that is, a person with sufficiently numerous and normal mature male and female gametocytes circulating in the peripheral blood,—the seed.

2. A female anopheline mosquito capable of acting as a beneficent host to malaria parasites must travel to the skin of the gametocyte carrier, push its proboscis into a blood vessel, and suck enough gametocytes into its gut to insure that it will become host to the critical number, or more, of sporozoites.

3. The mosquito that has thus successfully fed must live long enough and must maintain conditions of temperature and bodily state favorable enough to make possible the development of malaria parasites to the sporozoite stage, with lodgement of these sporozoites in the salivary glands.

4. This mosquito must make its way successfully to the skin of a susceptible person and inject a sufficient number of sporozoites to cause a new infection,—the sower and soil.

These fundamental and undisputed considerations remove much of the mystery from malaria epidemics, but they have not made the situation entirely clear. Anophelism sans malaria; malaria sans anophelism; years or regions of hyperendemicity; incidence regressions sans prophylaxis; recurrences coincident with active control; the effect of changed environment, of overcrowding, of malnutrition; these and other phenomena of malaria require further elucidation. The studies to which the present paper is an introduction have been undertaken in the hope that they may send light, however dim, into some of the hidden recesses of the epidemiology of malaria.

AVIAN MALARIA

The study of avian malaria has helped in the solution of some of the problems of human malaria. MacCallum's dicovery of the exflagellation of *Haemoproteus;*(144) Ross's momentous discovery of the transmission of *Proteosoma* by mosquitoes;(145) studies in relapse, drug therapy, biology and biometry of parasites, and host immunity in avian malaria by Whitmore,(146) the Sergents,(147) Roehl, and others,(148) Hartman,(149) and Huff(150) have augmented our understanding of human malaria.

It seems logical, therefore, to expect that a careful experimental study of epizoötics of malaria in laboratory birds may enrich our knowledge of the epidemiology of human malaria.

PROCEDURE

1. *Birds.*—The birds used in these experiments were canaries (*Serinus canarius*), purchased from dealers. Up to the time of writing this report two hundred canaries have been purchased and examined, all being negative. In no case has a bird infected with malaria been received from a dealer.

As will be seen below in the three preliminary reports of experiments, there was a high mortality in the first case but a low one in the second and third cases. This illustrates the fact that while some lots of canaries do poorly under laboratory conditions, others do very well.

2. *Parasites.*—The parasite used in all of these experiments was *Plasmodium cathemerium* Hartman, 1927.(151) In the first experiment the original Baltimore strain was used. In the last two experiments a strain isolated by Huff in Boston was used.(152) It is a matter of common knowledge among those who have worked with this plasmodium that canaries are susceptible to it. In over two hundred cases, in the experience of the author, it has invariably established itself in a bird upon needle inoculation. Successful transmission by mosquitoes occurred in the first and third experiments of this paper. It has also been reported by Huff(153) and others.

3. *Mosquitoes.*—The mosquito used in the first experiment was *Culex* (*Culex*) *pipiens* Linnæus, 1758. In the second and third experiments the species used was *Culex* (*Culex*) *quinquefasciatus* Say, 1823, (*C. fatigans*). That these species are susceptible to infection with avian malaria parasite has been shown in general for *C. quinquefasciatus* by Ross,(145) Daniels,(154) James,(155) and others. Huff(153) has shown in particular that

C. quinquefasciatus is susceptible to *P. cathemerium* Hartman, 1927. The susceptibility of *C. pipiens* has been demonstrated in general by Ruge,(156) the Sergeants,(157) and Neumann.(158) Huff (153) has shown in particular that *C. pipiens* is susceptible to *P. cathemerium* Hartman, 1927.

4. *Environment.*—The cages have been approximately 3 by 2 by 2 feet in size (Plate 1). In the first experiment the cage had glass sides and was kept in a special room equipped with thermostat and electric heater so adjusted that the temperature remained at about 80° F. (range 79° to 82° F. or 26.0° to 27.7° C.). High relative humidity was maintained. The birds were in a wire cage placed inside the mosquito cage in such a position that cleaning and feeding could be carried on with a minimum of disturbance.

The second and third experiments were done in Manila where the temperature is at no time unsuitable for mosquito breeding. Glass sides were not used in the Manila cages (Plate 2).

6. *Controlled factors.*—It will be realized from the foregoing paragraphs that many factors underlying the spread of malaria among birds could be manipulated in these experiments. A definite number of susceptible individuals were shut in a controlled area in close association with a definite number of gametocyte carriers. The carriers were changed from time to time, as indicated by daily blood smears, in order to keep a plentiful supply of gametocytes available.

Just how many gametocytes per 10,000 red blood cells are required to infect a mosquito is not known. It may be pointed out that Darling(159) found the limit of infectiousness in human malaria from *A. albimanus* to be one gametocyte per 500 leucocytes or 12 gametocytes per cubic millimeter of blood. As Huff(153) points out, if we assume the same to hold true for bird malaria and *C. quinquefasciatus* and assume further an anæmia of 2,500,000 red cells per cubic millimeter of blood, then a bird with only 0.048 gametocyte per 10,000 red cells would be infectious to mosquitoes.

In the experiments reported below, the carriers, with rare exceptions, were found upon examination to have 5 or more gametocytes per 10,000 red cells (see Tables 1, 2, and 3). If we assume with Huff, following Darling's work again, that an average blood meal is 0.0008 gram or 0.76 cubic millimeter (it is probably more) and also assume again an anæmia of 2,500,000 red cells per cubic millimeter of blood (it is probably not so

severe), then a single meal would mean 1,900,000 red cells and in the present experiments, 950 or more gametocytes (often several thousands).

TABLE 1.—*First experiment. Gametocyte counts.*

Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.	Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.
1929				1930			
April 17	2RH	++++	24	May 8	7RH	++++	730
April 18	2RH	+++	31	May 9	7RH	++++	619
April 19	2RH	+++	132	May 10	7RH	++++	988
April 20	115H	++++	163	May 11	8RH	+++	50
April 21	115H	++++	210	May 12	8RH	+++	32
April 22	115H	+++	92	May 13	8RH	+++	49
April 23	4RH	++++	20	May 14	8RH	++++	83
April 24	4RH	+++	8	May 15	8RH	+++	76
April 25	4RH	++	3	May 16	8RH	++++	51
April 26	3RH	+++	47	May 17	9RH	++	21
April 27	3RH	++++	108	May 18	9RH	++	17
April 28	4RH	+++	76	May 19	9RH	++	28
April 29	4RH	+++	55	May 20	9RH	++	7
April 30	6RH	+++	151	May 21	9RH	++	5
May 1	6RH	+++++	132	May 22	126H	+++	113
May 2	6RH	+++++	201	May 23	126H	++++	420
May 3	6RH	+++++	154	May 24	126H	++++	519
May 4	6RH	+++	95	May 25	43RE	+++++	581
May 5	6RH	++++	236	May 26	43RE	++++	690
May 6	6RH	++++	102	May 27	43RE	++++	834
May 7	7RH	++++	269				

TABLE 2.—*Second experiment. Gametocyte counts.*

Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.	Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.
1930				1930			
April 28	21R	++	1	June 9	51R	++	21
April 30	21R	+++++	114	June 10	43R	+++	31
May 1	21R	+++++	83	June 21	43R	+++++	1,070
May 4	21R	++++	42	June 24	33R	+	18
May 13	48R	++++	110	July 4	33R	+	5
May 14	48R	+++	155	July 7	34R	+	1
May 17	48R	++	95	July 10	34R	0	0
May 26	48R	+	5	July 13	U31	+	6
May 31	52R	++++	34	July 15	U30	++++	25
June 4	52R	+++++	14	July 18	U30	+++++	257
June 5	51R	+++++	317	July 24	U2	+++++	209

TABLE 3.—*Third experiment. Gametocyte counts.*

Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.	Date.	Bird No.	Smear.	Gametocytes per 10,000 red blood cells.
1930				1930			
August 14	U40	++++	310	August 30	U73	+++++	891
August 14	U41	++	35	August 30	U22	++++	364
August 14	U42	+++	29	August 30	U38	+++++	403
August 14	U36	+++	47	September 8	U84	+++++	905
August 21	U36	+++	54	September 8	U38	+	2
August 21	U88	++++	286	September 8	U93	++++	171
August 21	U89	+++	71	September 8	X12	+++++	238
August 21	U91	+++	92	September 16	U80	++	23
August 30	U37	+++++	1,037	September 16	J38	+++++	1,001

The mosquitoes were grown by the usual technic, for the most part inside the cage itself where feeding, mating, and egg-laying proceeded without difficulty. Daily counts were made of the adult mosquitoes, and from time to time increments of larvæ and pupæ were added to the cages (see Tables 5 and 6). Löffler's dehydrated blood serum mixed with litmus milk was found to be a satisfactory food for the larvæ. Raisins in sugar syrup were supplied for the male adult mosquitoes.

As to the susceptibility of the mosquitoes used in the first experiment it may be placed at about 45 per cent in accordance with results given in Table 4 of the very complete paper by Huff.(153) I was indebted to Huff for the stock of *C. pipiens*, which was the same as used in his experiments. At this point I would state that I am indebted to him not only for mosquito stock but also for generous criticism and guidance in many phases of this work.

In the second two experiments the susceptibility of the stock of *C. quinquefasciatus* may be placed for the purposes of this paper at about 48 per cent. This is based on one experiment where females of this species were allowed to feed on gametocyte-carrying birds so placed as to allow the insects leisurely and complete meals. Of thirty-one individuals that survived twelve days, fifteen on dissection were found to have oöcysts on the wall of the mid-gut. Experiments are in progress to determine the sporozoite rate which is lower.

As to the biting-frequency factor, data are being gathered but are not yet available.

As to the longevity of the mosquitoes in the experimental cages, Tables 4, 5, 6, and 7 give some preliminary information. Further observations are in progress.

TABLE 4.—*Experiment 5, cage E–H. Mortality of mosquitoes in an experiment cage (C. quinquefasciatus).*[a]

Date.	Adults counted.	Pupæ added.	Egg rafts removed.	Date.	Adults counted.	Pupæ added.	Egg rafts removed.
1931				1931			
January 20		176		February 11	37		
January 21	73	63		February 12	36		
January 22	100	160		February 13	26		
January 23	135	88		February 14	26		
January 24	192	138		February 15	10		
January 25	212	154		February 16	10		
January 26	295	74		February 17	9		
January 27	250	60	19	February 18	9		
January 28	280	42	8	February 19	9		
January 29	250		17	February 20	9		1
January 30	237			February 21	5		
January 31	137			February 22	5		
February 1	68			February 23	5		
February 2	110		4	February 24	5		
February 3	100		2	February 25	5		2
February 4	37			February 26	5		
February 5	37		1	February 27	2		
February 6	36			February 28	2		
February 7	39			March 1	1		
February 8	39			March 2	0		
February 9	39			March 3	0		
February 10	39			March 4	0		

[a] Throughout this experiment two birds were kept in the cage to supply blood meals. Raisins in syrup were supplied for the males.

FIRST EXPERIMENT

Chart 1 illustrates the following summary of experiment 1.

February 17, 1929. Three hundred fifty larvæ and pupæ of *C. pipiens* put in special cage with nine canaries (none infected); temperature, 85° F.; humidity, 95 per cent.

March 1. First egg raft found inside cage.

April 17. Mosquitoes in cage feeding, mating, laying eggs, and dying at such a rate that the daily count of females averages 100. Susceptible birds 1 to 9R put in cage. Also gametocyte carrier 2RH.

April 20. Gametocyte carrier 115H substituted for 2RH.

April 22. Susceptible 3R died with no evidence of malaria. 10R put in cage as replacement.

April 23. Gametocyte carrier 4RH substituted for 115H.

April 26. Gametocyte carrier 3RH substituted for 4RH.

April 28. Gametocyte carrier 4RH substituted for 3RH.

TABLE 5.—*Mosquito population during second experiment.*[a]

Date.	Mosquitoes counted.	Date.	Mosquitoes counted.	Date.	Mosquitoes counted.
1930		1930		1930	
May 16	758	June 15	405	July 15	635
May 17	877	June 16	415	July 16	639
May 18	894	June 17	421	July 17	653
May 19	888	June 18	378	July 18	635
May 20	829	June 19	271	July 19	651
May 21	815	June 20	372	July 20	496
May 22	798	June 21	307	July 21	571
May 23	749	June 22	343	July 22	492
May 24	817	June 23	408	July 23	516
May 25	791	June 24	478	July 24	543
May 26	644	June 25	435	July 25	535
May 27	569	June 26	456	July 26	454
May 28	442	June 27	557	July 27	418
May 29	338	June 28	576	July 28	445
May 30	310	June 29	604	July 29	496
May 31	312	June 30	621	July 30	530
June 1	319	July 1	846	July 31	513
June 2	382	July 2	812	August 1	460
June 3	383	July 3	880	August 2	458
June 4	364	July 4	746	August 3	456
June 5	456	July 5	669	August 4	457
June 6	457	July 6	663	August 5	432
June 7	496	July 7	692	August 6	429
June 8	503	July 8	677	August 7	421
June 9	403	July 9	656	August 8	412
June 10	440	July 10	683	August 9	438
June 11	405	July 11	669	August 10	441
June 12	459	July 12	783	August 11	482
June 13	420	July 13	718	August 12	439
June 14	413	July 14	727	August 19	425

[a] In this experiment the egg rafts were not removed from the cage. Additional pupæ were added from time to time as the population seemed to be falling. All counts were made at about 9 a. m. almost always by the same two individuals, their totals being averaged.

April 30. Gametocyte carrier 6RH substituted for 4RH.

May 3. Susceptible 1R died with no evidence of malaria; replaced by 11R.

May 4. Susceptible 4R died with no evidence of malaria; replaced by 12R.

May 5. If a maximum time of twelve days is allowed for development of sporozoites and six days for a prepatent period in a new infection, a case of malaria would appear on this day had a mosquito become infected the first night and lived to bite another bird on the twelfth day.

May 7. Gametocyte carrier 7RH substituted for 6RH. Susceptible 10R died with no evidence of malaria; replaced by 13R.

May 8. Susceptible 8R died with no evidence of malaria; replaced by 14R.

TABLE 6.—*Mosquito population during third experiment.*[a]

Date.	Mosquitoes counted.	Date.	Mosquitoes counted.	Date.	Mosquitoes counted.
1930		1930		1930	
August 15	806	August 28	557	September 9	834
August 16	881	August 29	459	September 10	949
August 17	859	August 30	629	September 11	896
August 18	847	August 31	792	September 12	1,061
August 19	779	September 1	1,043	September 13	863
August 20	757	September 2	875	September 14	834
August 21	723	September 3	735	September 15	849
August 22	670	September 4	631	September 16	961
August 23	390	September 5	639	September 17	863
August 24	423	September 6	812	September 18	743
August 25	518	September 7	821	September 19	705
August 26	662	September 8	814	September 20	717
August 27	548				

[a] In this experiment egg rafts were removed from the cage (see Table 7). Pupæ were added from time to time as the population seemed to be falling. The counts were made chiefly by one individual and usually at 9. a. m.

TABLE 7.—*Egg rafts removed from cage during third experiment.*

Date.	Egg rafts removed.	Date.	Egg rafts removed.	Date.	Egg rafts removed.	Date.	Egg rafts removed.
1930		1930		1930		1930	
August 19	5	August 30	47	September 14	6	September 23	2
August 20	5	August 31	52	September 15	5	September 24	36
August 21	4	September 3	10	September 16	5	September 25	23
August 22	15	September 5	3	September 17	2	September 26	0
August 23	1	September 6	106	September 18	32	September 27	0
August 24	6	September 8	22	September 19	64	September 28	28
August 25	3	September 9	66	September 20	6		
August 26	3	September 10	10	September 21	12		
August 28	7	September 11	36	September 22	2		

May 11. Gametocyte carrier 8RH substituted for 7RH. Susceptible 11R died with no evidence of malaria; replaced by 15R.

May 14. Susceptible 2R and 13R died with no evidence of malaria; replaced by 16R and 17R.

May 17. Gametocyte carrier 9RH substituted for 8RH.

May 22. Gametocyte carrier 126H substituted for 9RH.

May 23. Susceptible 6R and 16R died with no evidence of malaria; replaced by 11RH and 13RH.

May 25. Gametocyte carrier 43RE substituted for 126H. Susceptible 5R and 15R died with no evidence of malaria; not replaced because birds not available.

May 27. Replacements 37RE and 40RE put in cage. This day is notable for the fact that both 12R and 14R have positive blood smears.

May 29. Susceptible 17R died with no evidence of malaria; not replaced.

May 30. Replacement 45RE.

June 4. Bird 12R died of acute malaria.

June 5. Bird 9R has a positive blood smear. It has been in the cage since April 17 and escaped infection from about April 29 to about May 30.

May 6. Bird 14R died of acute malaria.

May 7. Bird 40E died with no evidence of malaria.

May 9. Bird 45RE died with no evidence of malaria.

May 11. Experiment stopped.

DISCUSSION OF FIRST EXPERIMENT

This first experiment was carried through to develop technic. It demonstrated that *C. pipiens* will propagate itself and maintain a colony in an experimental cage such as described. It made evident that *C. pipiens* feeds readily on birds in cages and that it will transmit malaria under these conditions. It also demonstrated that a high mortality may come about among birds free from malaria but purchased in the open market and kept under laboratory conditions. Each dead bird was carefully examined post mortem for evidence of malaria. Except in the cases of 12R and 14R no such evidence was found. The other birds died of a bacterial infection. This bacterial epidemic coincident with the experiment illustrates one of the occasional major difficulties in the study of avian malaria.

SECOND EXPERIMENT

Chart 2 illustrates the second experiment. Having moved from Boston to Manila it became necessary for me to develop a technic suited to different climatic conditions. This second experiment and the third are to be viewed in a preliminary way.

April 5, 1930. Four pans well stocked with larvæ and pupæ of *C. quinquefasciatus* put in cage with five birds.

April 12. First egg rafts.

April 27. Colony of mosquitoes is propagating itself strongly.

April 28. Susceptible birds XI, 2, 3, 4, 5, 6, 8, 9, and 10 put in cage. Also gametocyte carrier 21R.

May 13. Gametocyte carrier 48R substituted for 21R.

May 27. Gametocyte carrier 52R substituted for 48R.

June 4. Gametocyte carrier 51R substituted for 52R.

June 10. Gametocyte carrier 43R substituted for 51R.

June 21. Gametocyte carrier 33R substituted for 43R.

July 7. Gametocyte carrier 34R substituted for 33R.

July 11. Gametocyte carrier U31 substituted for 34R.

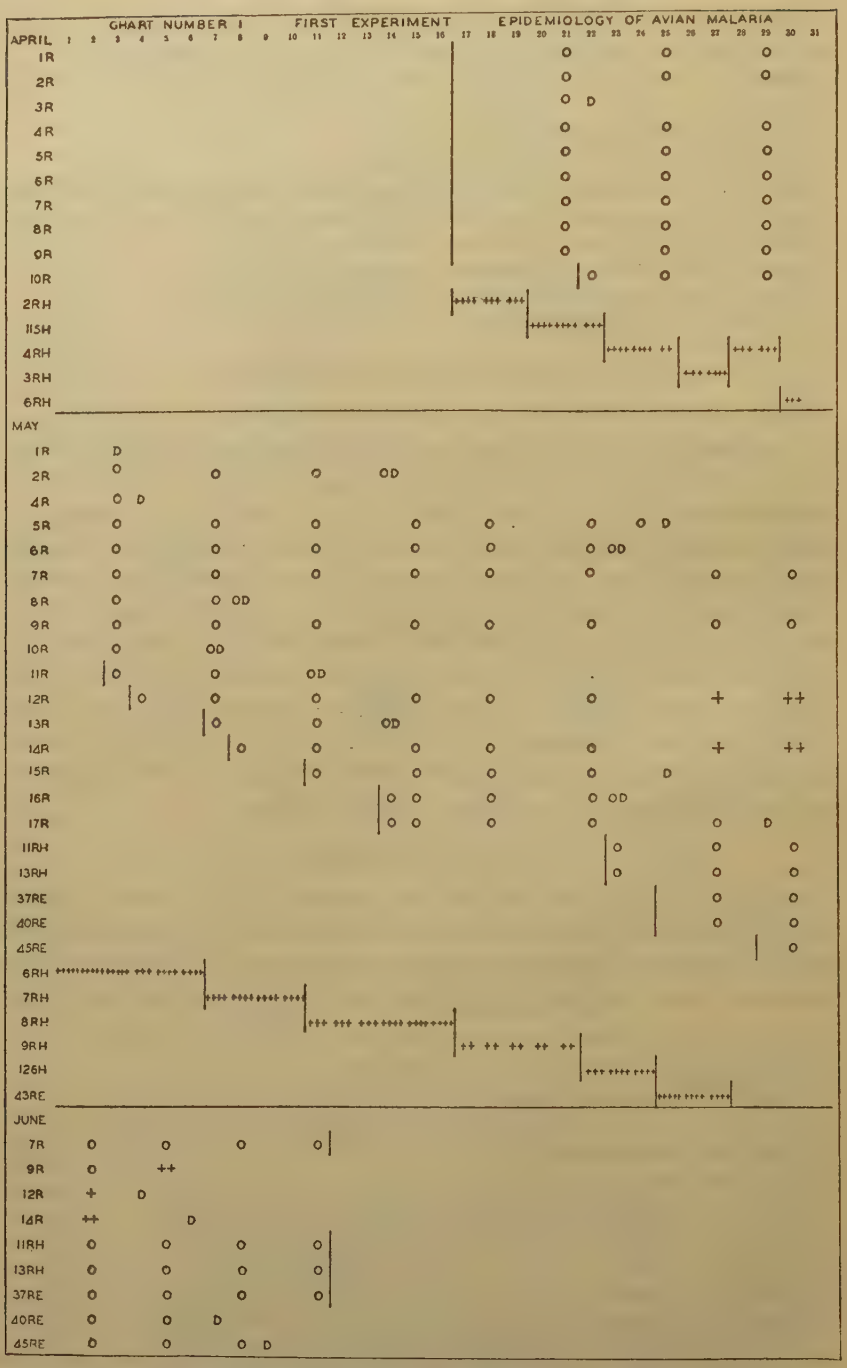

Fig. 1. Chart 1, first experiment, epidemiology of avian malaria.

July 14. Gametocyte carrier U30 substituted for U31.

July 22. Gametocyte carrier U2 substituted for U30.

July 24. X8 died with no evidence of malaria. This is the first bird to die in the cage since the beginning of the experiment. Gametocyte carrier U2 removed and not replaced.

July 28. X9 died with no evidence of malaria.

August 7. X2 died with no evidence of malaria.

August 12. Experiment discontinued. There has been no transmission of malaria whatever in this experiment, yet at all times there have been gametocytes available.

DISCUSSION OF SECOND EXPERIMENT

In order to test the susceptibility of the birds in this experiment X1, 3, 4, 5, 6, and 10 were inoculated by needle with the same strain of malaria plasmodium on dates as shown in fig. 2. Birds X3 and X10 died before becoming positive, four and two days, respectively, after inoculation. The other four birds became positive after the usual prepatent periods, showing that they were susceptible and proving that they had not previously been infected by the mosquitoes.

The same strain of mosquitoes was used in the third experiment (see below) and they were thereby also proved to be susceptible.

In this second experiment we therefore had a situation corresponding somewhat to anophelism sans malaria. The mosquitoes readily fed on the population and were not diverted to other animals, as is sometimes the case in nature where anophelism sans malaria exists. At all times 10 per cent (one bird) of the population carried gametocytes, yet malaria did not spread. There was too high mortality among the mosquitoes and there were too few gametocyte carriers. The mosquito turnover was much higher in this experiment than in the first.

The "epidemic potential" in this second experiment was not high enough. This term, "epidemic potential," was suggested by Peters,(160) whose book is not available to this author. Topley defines Peters's term as "the balance of interacting forces which tends towards the occurrence of an outbreak of disease." It is a good term to replace Sydenham's ill-defined "epidemic constitution," which seems to have been forced back into use by the last pandemic of influenza, an occurrence that was and is inexplicable in terms of modern epidemiology. "Epidemic potential," as a term, helps not at all toward fundamental explanations, yet it more aptly expresses the modern view.

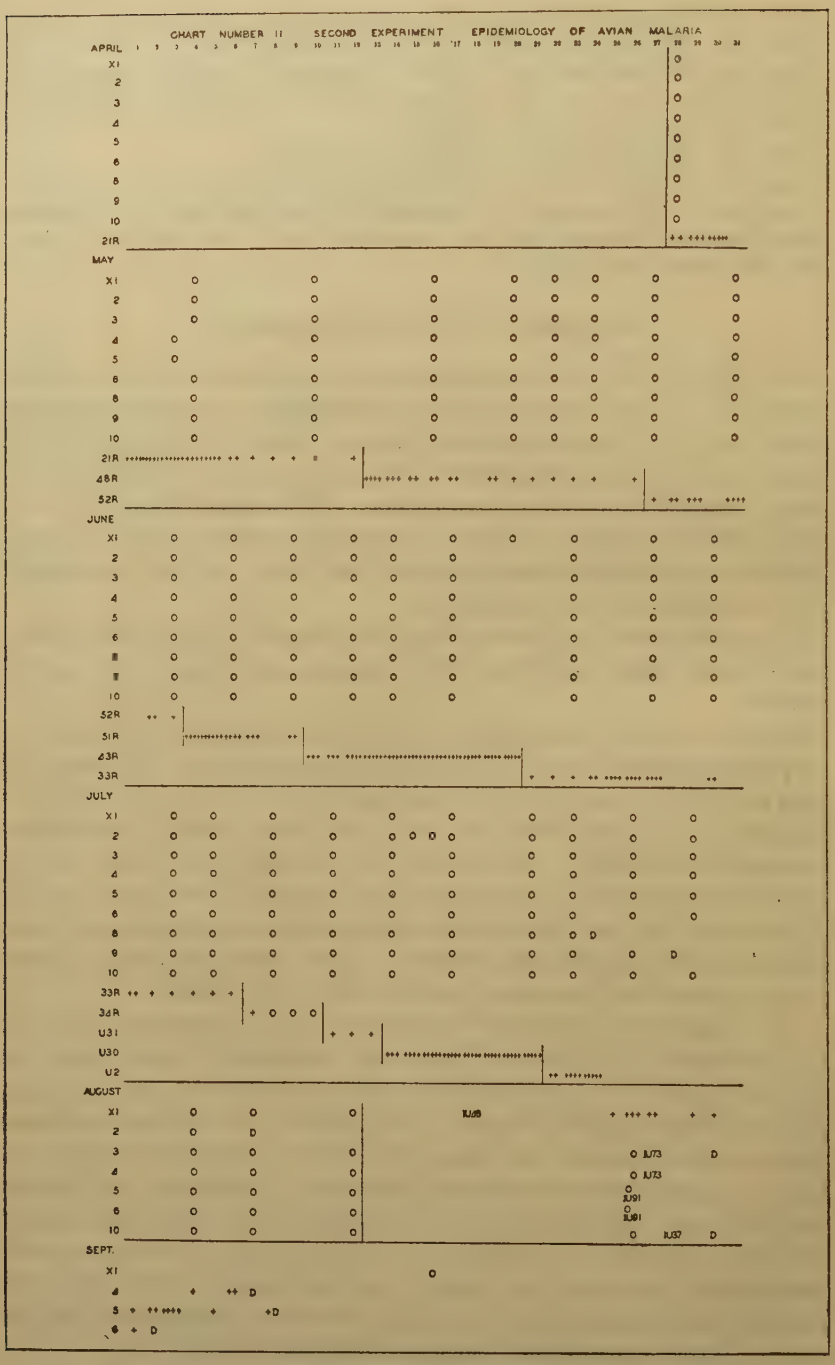

FIG. 2. Chart 2, second experiment, epidemiology of avian malaria.

THIRD EXPERIMENT

A colony of *C. quinquefasciatus* having established itself in a cage, the experiment was started.

August 14, 1930. Susceptible bird X13 put in cage with gametocyte carriers U36, U40, U41, and U42.
August 19. Gametocyte carriers U48 and U88 substituted for U41 and U42.
August 21. Gametocyte carriers U89 and U91 substituted for U40 and U48.
August 23. Gametocyte carrier U90 substituted for U36.
August 27. Gametocyte carriers U37 and U73 substituted for U88 and U89.
August 28. Gametocyte carriers U90 and U91 removed from cage.
August 29. Gametocyte carriers U22 and U38 put in cage.
September 2. Gametocyte carriers U68, U69, U72 substituted for U22, U37 and U73.
September 5. Gametocyte carriers U92, U93, and X12 substituted for U68, U69, and U92.
September 6. Gametocyte carrier U92 removed from cage.
September 8. Gametocyte carrier U84 put in cage.
September 9. Gametocyte carriers U78 and J17 substituted for U38 and X12.
September 11. Gametocyte carrier J18 substituted for U93.
September 12. Gametocyte carrier J22 substituted for U84.
September 13. Gametocyte carrier J40 substituted for J22.
September 15. Gametocyte carriers U80 anad J38 substituted for U78 and J40.
September 17. X13 has a positive blood smear. Experiment ended.

DISCUSSION OF THIRD EXPERIMENT

Here we had a condition simulating an area in which malaria is hyperendemic and into which a susceptible individual comes. Eighty per cent of the population carried gametocytes in their blood. There were mosquitoes in abundance. It was a foregone conclusion that the susceptible would become infected.

The mosquito turnover in this third experiment was comparable to that in the second where no transmission of malaria took place. But here the "epidemic potential" was high.

These first experiments are not to be analyzed too closely mathematically. It has been necessary to proceed slowly and to develop technical facility. This report is made as an introductory one because it seems to point towards an experimental procedure in the study of the epidemiology of malaria which may lead to a better understanding of fundamental relationships.

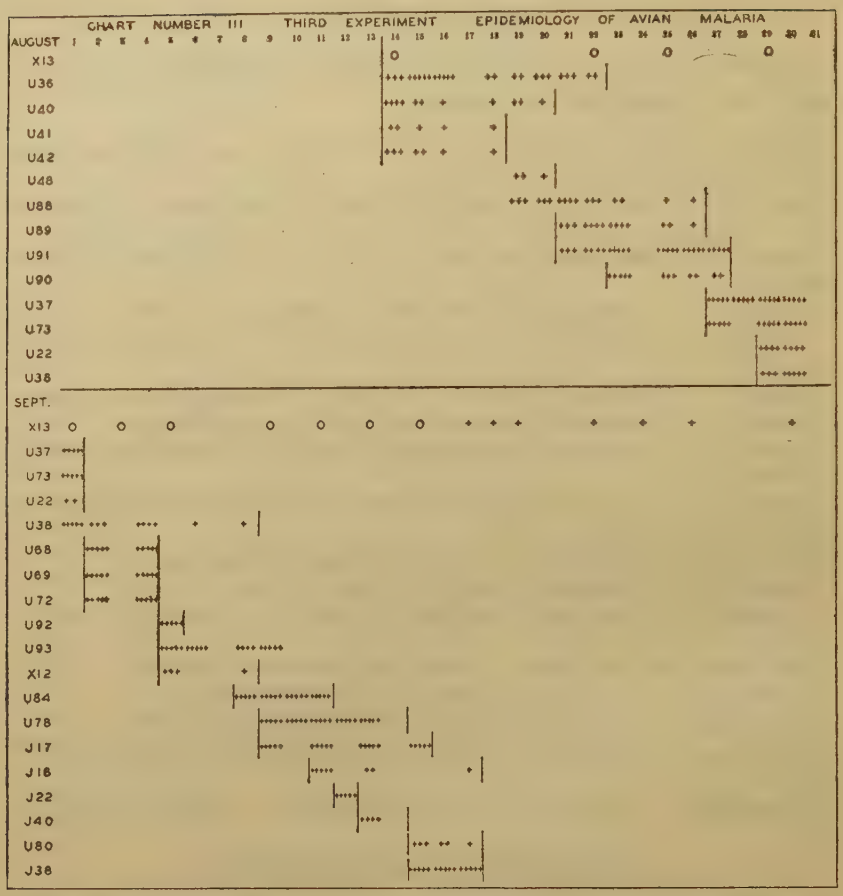

FIG. 3. Chart 3, third experiment, epidemiology of avian malaria.

SUMMARY

The subject of experimental epidemiology is briefly discussed with especial reference to malaria. Three preliminary experiments in the epidemiology of avian malaria are reported with a discussion of technic and results. A bibliography is appended.

REFERENCES

1. Hippocrates (Loeb's Classics). Tr. by W. H. S. Jones. Heinemann, London 1 (1923).
2. BALLONII, G. Epidemiorum et Ephemeridum libri II. Paris (1640).
3. SYDENHAM, T. Opera Omnia. Tr. by R. G. Latham. London (1849) 2 volumes.
4. MAGELSSEN, A. Genius epidemicus. Jannus, Amsterdam 11 (1906) 561–575.

5. GREENWOOD, M. Sydenham as an epidemiologist. Proc. Roy. Soc. Med. (Sec. Epidem. & State Med.) 12 (1919) 56–76.
6. GOODALL, E. W. The epidemic constitution. Proc. Roy. Soc. Med. (Sec. Epidem. & State Med.) 21 (1927–28) 119–128.
7. HAMER, W. H. Epidemic disease in England. The evidence of variability and of persistency of type. Lecture I. Lancet 1 (1906) 569–574; Lecture II, 655–662; Lecture III, 733–739.
8. HAMER, W. H. Int. Congress of Med. Sec. 23 (1913) 305.
9. HAMER, W. H. The epidemiology of cerebrospinal fever. Proc. Roy. Soc. (Sec. Epidem. & State Med.) II 10 (1916) 17–44.
10. HAMER, W. H. Proc. Roy. Soc. (Sec. Epidem. & State Med.) (1923) 55.
11. CROOKSHANK, F. G. First principles: and epidemiology. Proc. Roy. Soc. Med. (Sec. Epidem. & State Med.) 13 (1920) 159–184.
12. CROOKSHANK, F. G. First principles: and epidemiology. Proc. Roy. Soc. Med. 13 (1919–20) 159–184. Epidem. Sec.
13. GREENWOOD, M. The factors that determine the rise, spread and degree of severity of epidemic diseases. 17th Internat. Congress Med. Sec. 18 (1913) 49.
14. BROWNLEE, JOHN. Certain considerations on the causation and course of epidemics. Proc. Roy. Soc. Med. Part 2 2 (June, 1909) 243.
15. BROWNLEE, J. The mathematical theory of random migration and epidemic distribution. Proc. Roy. Soc. Edinburgh Part 2 31 (1910) 262–289.
16. BROWNLEE, J. On the curve of the epidemic. Brit. Med. Journ. (May 8, 1915) 799–800.
17. BROWNLEE, J. An investigation into the periodicity of measles epidemics in London from 1703 to the present day by the method of the periodogram. Philos. Trans. Roy. Soc. § B 208 (1917–1918) 225–250.
18. BROWNLEE, J. An investigation into the periodicity of measles epidemics in the different districts of London for the years 1890–1912. Philos. Trans. Roy. Soc. § B 209 (1919–1920) 181–190.
19. ROSS, RONALD. The logical basis of the sanitary policy of mosquito reduction. Brit. Med. Journ. (May 13, 1905) 1025–1029.
20. ROSS, R. Report on the Prevention of Malaria in Mauritius. Waterlow & Sons, London (1908) 29–40.
21. ROSS, R. The Prevention of Malaria 1st ed. John Murray, London (1910).
22. ROSS, R. The Prevention of Malaria. 2d. ed. John Murray, London Special Addendum on the Theory of Happenings (1911) 651–686.
23. ROSS, R. Some quantitative studies in epidemiology. Nature (October 5, 1911) 466, 67.
24. ROSS, R. Some a priori pathometric equations. Brit. Med. Journ. (March 27, 1915) 546.
25. ROSS, R. An application of the theory of probabilities to the study of a priori pathometry, Part I. Proc. Roy. Soc. London Ser. A 92 (February 1, 1916) 204–230.
26. ROSS, R., and H. P. HUDSON. An application of the theory of probabilities to the study of a priori pathometry, Parts II and III. Proc. Roy. Soc. London Ser. A, No. 650 93 (1917) 212–239.

27. LOTKA, A. J. Quantitative studies in epidemiology. Nature (February 8, 1912) 497, 98.
28. LOTKA, A. J. Science Progress 14 (1913) 413.
29. LOTKA, A. J. Contribution to the analysis of malaria epidemiology. Parts I–V. Am. Journ. Hyg. 3 (January supplement, 1923).
30. WAITE, H. Mosquitoes and malaria. Biometrika No. 4 7 (1910) 421–436.
31. MCKENDRICK, A. G. On certain mathematical aspects of malaria. Paludism No. 4 (March, 1912) 54–63.
32. KERMACK, W. O., and A. G. MCKENDRICK. A contribution to the mathematical theory of epidemics. Proc. Roy. Soc. London Ser. A, No. 772 115 (August, 1927) 700–721.
33. LÖFFLER, F. Die Feldmausplage in Thessalien und ihre erfolgreiche Bekampfung mittels des Bacillus typhi murium. Centralbl. fur Bakteriol. No. 1 12 (1892) 1–17.
34. DANYSZ, J. Un microbe pathojene pour les rats. Ann. Inst. Pasteur 14 (1900) 193–201.
35. DANYSZ, J. Some reflections regarding the free use of bacteriological cultures for the destruction of rats and mice. Brit. Med. Journ. 1 (1909) 209, 10.
36. BAHR, L. Ueber die zur Vertilgung von Ratten und Mausen benutzten Bakterien. Centralbl. f. Bakteriol. u. Parasitenk., Jena 34 (1905) 263–276.
37. LISTON. Report of Bombay Bacteriol. Lab. (1907).
38. Xylander. Arb. a. d. Kaiserlich Gesundheitsamte Berlin 28 (1908) 145.
39. MÜHLENS, DAHNS, and FÜRST. Untersuchungen uber Bakterien der Enteritis-Gruppe (Typhus Gartner und Typus Flujje) insbesondere uber die sogenannten "Fleiochvergiftungserreger" und die sogenannter "Rattenschadlinge." Centralbl. f. Bakteriol. u. Parasitenk., Jena 1 Abt. Orig. Bd. 48 (1909) 1.
40. BAINBRIDGE, F. A. On the paratyphoid and "food-poisoning" bacilli and on the nature and efficiency of certain rat viruses. Journ. Path. & Bact. 13 (1909) 443–466.
41. TOPLEY, W. W. C. The spread of bacterial infection, I & II. Lancet No. 5001 197 (July 5, 1919) 1–5.
42. TOPLEY, W. W. C. The spread of bacterial infection, II, ctd. Lancet No. 5002 197 (July 12, 1919).
43. TOPLEY, W. W. C. The spread of bacterial infection, III. Lancet No. 5003 197 (July 19, 1919).
44. TOPLEY, W. W. C. The spread of bacterial infection. Some characteristics of long-continued epidemics. Journ. Hyg. 19 (1921) 350–379.
45. TOPLEY, W. W. C. The spread of bacterial infection. The potential infectivity of a surviving mouse-population and their resistance to subsequent epidemics of the same disease. Journ. Hyg. 20 (1921) 103–109.
46. TOPLEY, W. W. C. The spread of bacterial infection. Some characteristics of the pre-epidemic phase. Journ. Hyg. 21 (1922) 10–19.

47. TOPLEY, W. W. C. The spread of bacterial infection. The effect of dispersal during the pre-epidemic stage and of subsequent reaggregation. Journ. Hyg. 21 (1922) 20–32.

48. TOPLEY, W. W. C. The spread of bacterial infection. Some general considerations. Journ. Hyg. 21 (1923) 226–236.

49. TOPLEY, W. W. C., and G. S. WILSON. The spread of bacterial infection. Group-to-group infection. Journ. Hyg. 21 (1923) 237–243.

50. TOPLEY, W. W. C., and G. S. WILSON. The spread of bacterial infection. The problem of herd-immunity. Journ. Hyg. 21 (1923) 243–249.

51. TOPLEY, W. W. C., and J. ARYTON. A technique for measuring the excretion of bacilli of the enteric group in the faeces of infected mice. Journ. Hyg. 22 (1924) 222–233.

52. TOPLEY, W. W. C., and J. ARYTON. The excretion of B. enteritidis (aertrycke) in the faeces of mice after administration by mouth. Journ. Hyg. 22 (1924) 234–263.

53. TOPLEY, W. W. C., and J. ARYTON. The segregation of biological factors in B. enteritidis (aertrycke). A report to the Medical Research Council. Journ. Hyg. 22 (1924) 305–313.

54. TOPLEY, W. W. C., and J. ARYTON. Further investigations into the biological characteristics of B. enteritidis (aertrycke). Journ. Hyg. 23 (1924) 198–222.

55. TOPLEY, W. W. C., J. ARYTON, and E. R. LEWIS. The spread of bacterial infection. Further studies on an experimental epidemic of mouse typhoid. Journ. Hyg. 23 (1924) 223–240.

56. TOPLEY, W. W. C., J. WILSON, and E. R. LEWIS. Immunization and selection as factors in herd-resistance. Journ. Hyg. 23 (1925) 421–436.

57. TOPLEY, W. W. C., J. WILSON, and E. R. LEWIS. The role of the Twort-d'Herelle phenomenon in epidemics of mouse-typhoid. Journ. Hyg. 24 (1925) 17–36.

58. GREENWOOD, M., and W. W. C. TOPLEY. A further contribution to the experimental study of epidemiology. Journ. Hyg. 24 (1925) 45–110.

59. TOPLEY, W. W. C., and J. WILSON. Further observations on the rôle of the Twort-d'Herelle phenomenon in the epidemic spread of mouse-typhoid. Journ. Hyg. 24 (1925) 295–300.

60. LOCKHART, L. P. The measurement of bacterial virulence and of certain allied properties with special reference to the virulence of B. aertrycke. Journ. Hyg. 25 (1926) 50–89.

61. WILSON, G. S. The relation between the age and the virulence of cultures of B. aertrycke (Mutton). Journ. Hyg. 25 (1926) 142–149.

62. GREENWOOD, M., and W. W. C. TOPLEY. Experimental epidemiology—Some general considerations. Proc. Roy. Soc. Med. (Sec. Epidem. & State Med.) 19 (1926) 31–44.

63. TOPLEY, W. W. C. Experimental epidemiology. First part. Lancet. 1 (March 6, 1926) 477–484.

64. TOPLEY, W. W. C. Experimental epidemiology. Second part. Lancet 1 (March 13, 1926) 531–537.

65. TOPLEY, W. W. C. Experimental epidemiology. Third part. Lancet 1 (March 27, 1926) 645–651.

66. GREENWOOD, M., E. M. NEWBOLD, W. W. C. TOPLEY, and J. WILSON. On the mechanisms by which protection against infectious disease is acquired in "natural" epidemics. Journ. Hyg. 25 (1926) 336–353.

67. TOPLEY, W. W. C. Quantitative experiments in the study of infection and resistance. Journ. State Med. 35 (January, 1927) 2–24.

68. NEWBOLD, E. M. Appendix to the paper by M. Greenwood, E. M. Newbold, W. W. C. Topley, and J. Wilson, "On the mechanisms by which protection against infectious disease is acquired in 'natural' epidemics." Journ. Hyg. 26 (1927) 19–27.

69. WILSON, G. S. A spontaneous epidemic in mice associated with Moyan's bacillus and its bearing on the aetiology of summer diarrhoea. Journ. Hyg. 26 (1927) 170–186.

70. TOPLEY, W. W. C., M. GREENWOOD, J. WILSON, and E. M. NEWBOLD, Epidemic potency of strains of B. aertrycke of varying virulence. Journ. Hyg. 27 (June, 1928) 396–411.

71. GREENWOOD, M., E. M. NEWBOLD, W. W. C. TOPLEY, and J. WILSON. Mechanism of protection against infective disease. Journ. Hyg. 28 (November, 1928) 127–132.

72. TOPLEY, W. W. C. Experimental epidemiology. Seuchen bekampfung. 6 (1929) 188–223.

73. FLEXNER, SIMON. Experimental epidemiology—Introductory. Journ. Exp. Med. 36 (1922) 9–14.

74. LYNCH, C. J. An outbreak of mouse typhoid and its attempted control by vaccination. Journ. Exp. Med. 36 (1922) 15–24.

75. AMOSS, H. L. Experimental epidemiology. I. An artificially induced epidemic of mouse typhoid. Journ. Exp. Med. 36 (1922) 25–44.

76. AMOSS, H. L. Experimental epidemiology. II. Effect of the addition of healthy mice to a population suffering from mouse typhoid. Journ. Exp. Med. 36 (1922) 45–70.

77. WEBSTER, L. T. Experiments on normal and immune mice with a Bacillus of mouse typhoid. Journ. Exp. Med. 36 (1922) 71–96.

78. WEBSTER, L. T. Identification of a paratyphoid-enteritidis strain associated with epizoötics of mouse typhoid. Journ. Exp. Med. 36 (1922) 97–106.

79. AMOSS, H. L., and P. P. HASELBANER. Immunological distributions of two strains of the mouse typhoid group isolated during two spontaneous outbreaks among the same stock. Journ. Exp. Med. 36 (1922) 107–114.

80. WEBSTER, L. T. The intestinal flora in mouse typhoid infection. Journ. Exp. Med. 37 (1923) 21–32.

81. WEBSTER, L. T. Ox bile sensitization in mouse typhoid infection. Journ. Exp. Med. 37 (1923) 33–42.

82. WEBSTER, L. T. Microbic virulence and host susceptibility in mouse typhoid infection. Journ. Exp. Med. 37 (1923) 231–268.

83. WEBSTER, L. T. Contribution to the manner of spread of mouse typhoid infection. Journ. Exp. Med. 37 (1923) 269–274.

84. WEBSTER, L. T. The virulence of an epidemic strain of Bacillus pestis paviae. Journ. Exp. Med. 37 (1923) 781–788.

85. WEBSTER, L. T. Microbic virulence and host susceptibility in paratyphoid in enteritidis infection in white mice I. Journ. Exp. Med. 38 (1923) 33–44.

86. WEBSTER, L. T. Microbic virulence and host susceptibility in paratyphoid in enteritidis infection of white mice II. Journ. Exp. Med. 38 (1923) 45–54.

87. WEBSTER, L. T. Microbic virulence and host susceptibility in paratyphoid-enteritidis infections of white mice III. The immunity of a surviving population. Journ. Exp. Med. 39 (1924) 129–136.

88. PRITCHETT, I. W. Homologous and heterologous protection in mice vaccinated with the two types of mouse typhoid bacillus. Journ. Exp. Med. 39 (1924) 265–274.

89. WEBSTER, L. T. The epidemiology of a rabbit respiratory infection I. Introduction. Journ. Exp. Med. 39 (1924) 837–842.

90. WEBSTER, L. T. The epidemiology of a rabbit respiratory infection II. Clinical, pathological and bacteriological study of snuffles. Journ. Exp. Med. 39 (1924) 843–856.

91. WEBSTER, L. T. The epidemiology of a rabbit respiratory infection III. Nasal flora of laboratory rabbits. Journ. Exp. Med. 39 (1924) 857–878.

92. WEBSTER, L. T. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection in white mice IV. The effect of selective breeding on host resistance. Journ. Exp. Med. 39 (1924) 879.

93. WEBSTER, L. T. The epidemiology of a rabbit respiratory infection IV. Susceptibility of rabbits to spontaneous snuffles. Journ. Exp. Med. 11 (1924) 109–116.

94. WEBSTER, L. T. The epidemiology of a rabbit respiratory infection V. Experimental snuffles. Journ. Exp. Med. 11 (1924) 117–128.

95. WEBSTER, L. T., and I. W. PRITCHETT. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice. V. The effect of diet on host resistance. Journ. Exp. Med. 40 (1924) 397–404.

96. WEBSTER, L. T. The application of experimental methods to epidemiology. Am. Journ. Hyg. 4 (1924) 134–142.

97. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice. VI. The relative susceptibility of different strains of mice to per os infection with Type II bacillus of mouse typhoid (Bacillus pestis caviae). Journ. Exp. Med. 12 (1925) 195–208.

98. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice. VII. Seasonal variation in the susceptibility of different strains of mice to per os infection with the Type II bacillus of mouse typhoid (Bacillus pestis caviae). Journ. Exp. Med. 12 (1925) 209–214.

99. WEBSTER, L. T., and I. W. PRITCHETT. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice. VIII. The effect of selective breeding on host resistance. Further studies. Journ. Exp. Med. 13 (1925) 1–8.

100. WEBSTER, L. T. Further contribution of experimental methods to the study of epidemics. Am. Journ. Hyg. 5 (1925) 335–341.

101. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice: relationship of dosage to mortality rate, survival time and cage population. Journ. Exp. Med. 43 (February, 1926) 143–159.

102. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice: relative susceptibility of different strains of mice to per os infection with type II bacillus of mouse typhoid (B. pestis caviae). Journ. Exp. Med. 43 (February, 1926) 161–171.

103. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice: seasonal variation in susceptibility of different strains of mice to per os infection with type II bacillus of mouse typhoid (B. pestis caviae). Journ. Exp. Med. 43 (February, 1926) 173–177.

104. WEBSTER, L. T. Epidemiological studies on respiratory infections of rabbits: pneumonias associated with B. lepisepticum. Journ. Exp. Med. 43 (April, 1926) 555–72.

105. WEBSTER, L. T. Epidemiological studies on respiratory infections of rabbits: carriers of B. lepisepticum. Journ. Exp. Med. 43 (April, 1926) 573–590.

106. FLEXNER, S. Advancement of epidemiology through experiment, I. Am. Journ. Med. Sci. 171 (April, 1926) 469–479.

107. FLEXNER, S. Advancement of epidemiology through experiment, II. Experimental results. Am. Journ. Med. Sci. 171 (May, 1926) 625–635.

108. WEBSTER, L. T., and C. G. BURN. Biology of Bacterium lepisepticum, III. Physical cultural and growth characteristics of diffuse and mucoid types and their variants. Journ. Exp. Med. 44 (September, 1926) 343–358.

109. WEBSTER, L. T., and C. G. BURN. Biology of Bacterium lepisepticum, IV. Virulence of diffuse and mucoid types and their variants. Journ. Exp. Med. 44 (September, 1926) 359–386.

110. WEBSTER, L. T. Epidemic prevalence in light of experimental findings. Journ. Clin. Investigations 3 (February, 1927) 465–473.

111. FLEXNER, S. Advancement of epidemiology through experiment. Porto Rico Health Rev. 2 (April, 1927) 3.

112. FLEXNER, S. Advancement of epidemiology through experiment. Porto Rico Health Rev. 2 (May, 1927) 9.

113. WEBSTER, L. T. Epidemiological studies on respiratory infections of rabbits, IX. Spread of B. lepisepticum infection at a rabbit farm in New York City, New York. An epidemiological Study. Journ. Exp. Med. 45 (March, 1927) 529–551.

114. SMITH, DAVID T. Epidemiological studies on respiratory infections of the rabbit. X. A spontaneous epidemic of pneumonia and snuffles caused by Bacterium lepisepticum among stock of rabbits at Saranac Lake, N. Y. Journ. Exp. Med. 45 (1927) 553–560.

115. WEBSTER, L. T. and C. BURN. Bacterium lepisepticum infection: its mode of spread and control. Journ. Exp. Med. 45 (May, 1927) 911–935.

116. PRITCHETT, I. W. Microbic virulence and host susceptibility in paratyphoid-enteritidis infection of white mice, XII. Effect of diet on host resistance. Further studies. Journ. Exp. Med. 46 (October, 1927) 557–570.

117. WEBSTER, L. T., and I. W. PRITCHETT. Studies on mode of spread of B. enteritidis mouse typhoid infection, II. Native epidemicity. Journ. Exp. Med. 46 (December, 1927) 847–853.

118. WEBSTER, L. T., and C. BURN. Studies on mode of spread of B. enteritidis mouse typhoid infection, II. Effects of external conditions on occurrence of smooth, mucoid and rough colony types. Journ. Exp. Med. 46 (December, 1927) 855–870.

119. WEBSTER, L. T., and C. BURN. Studies on mode of spread of B. enteritidis mouse typhoid infection, III. Studies of bacterial cells taken from smooth, mucoid, and rough colonies. Journ. Exp. Med. 46 (December, 1927) 871–886.

120. WEBSTER, L. T., and C. BURN. Studies on mode of spread of B. enteritidis mouse typhoid infection, IV. The relative virulence of smooth, mucoid and rough strains. Journ. Exp. Med. 46 (December 1927) 887–907.

121. WEBSTER, L. T. Recent knowledge of epidemics. Bull. New York Acad. Med. 4 (January, 1928) 20–26.

122. WEBSTER, L. T. Mode of spread of Friedlander bacillus-like respiratory infection of mice. Journ. Exp. Med. 47 (May, 1928) 685–712.

123. WEBSTER, L. T. Epidemiology of fowl cholera-experimental studies. I. Introduction. Journ. Exp. Med. 51 (February, 1930) 219–223.

124. LANGE, B. Untersuchungen uber Superinfektion. Zeitschr. f. Hyg. 94 (1921) 135–151.

125. LANGE, B., and M. YOSHIOKA. Beobachtungen uber Infektion und Immunitat beim Mausetyphus. Zeitschr. f. Hyg. 101 (1924) 451–465.

126. NEUFELD, F. Uber einige grundsatzliche Fragen der aktiven Immunisierung. Zeitschr. f. Hyg. 101 (1924) 466–490.

127. LANGE, B. Uber die Infektion von Weissen Mausen auf den Naturlichen Wegen durch die Haut, die Mund-und Darmschlemhaut sowie die Augenbindehaut. Zeitschr. f. Hyg. 102 (1924) 224–261.

128. NEUFELD, F. Uber die verschiedene Empfanglichkeit junger und erwachsener Individuen fur Infectionen und ihre Ursachen. Zeitschr. f. Hyg. 103 (1924) 471–482.

129. LANGE, B., and K. H. KESCHISCHIAN. Uber Versuch, weisse Mase durch Einatmung von Krankheitserregern zu infigieren. Zeitschr. f. Hyg. 103 (1924) 569–583.

130. NEUFELD, F. Experimentelle Epidemiologie. Kritischer Bericht uber einige neuere Forschungsergebnisse. Klinische Wochensch Part II 3 (1924) 1345–1351.

131. NEUFELD, F. Experimental epidemiologic experiments. Deutsche Med. Wochenschr. 51 (February 27, 1925) 341–344. Also Journ. Am. Med. Assoc. 84 (April 18, 1925) 1242.

132. OKAMOTO, T. Epidemiologische Beobachtungen an Mausen und Neerschweinchen. Klin. Wochenschr. 5 (April, 1926) 795–796. Japan Med. World 6 (August, 1926) 210–213. Abs. Journ. Am. Med. Assoc. 86 (June, 1926) 2006.

133. NEUFELD, F. Natural immunity in its significance for epidemiology. De Lamar Lectures (1926–1927) 1–12.

134. PERLA, D. Experimental epidemiology of tuberculosis. Journ. Exp. Med. 45 (1927) 209–226.

135. PERLA, D. Experimental epidemiology of tuberculosis. The elimination of tubercle bacilli in the feces, bile and urine of infected guinea pigs. Journ. Exp. Med. 45 (1927) 1025–1036.

136. LURIE, M. B. Experimental epidemiology of tuberculosis. The effect of crowding upon tuberculosis in guinea pigs, acquired by contact and by inoculation. Journ. Exp. Med. 51 (1930) 729–741.

137. LURIE, M. B. Experimental epidemiology of tuberculosis. Air-borne contagion of tuberculosis in an animal room. Journ. Exp. Med. 51 (1930) 743–751.

138. LURIE, M. B. Experimental epidemiology of tuberculosis. The route of infection in naturally acquired tuberculosis of the guinea pig. Journ. Exp. Med. 51 (1930) 769–775.

139. LURIE, M. B. Experimental epidemiology of tuberculosis. The effect of eliminating exposure to enteric infection on the incidence and course of tuberculosis acquired by normal guinea pigs confined with tuberculous cage mates. Journ. Exp. Med. 51 (1930) 753–767.

140. KOCH, R. Gesammelte Werke von R. Koch, Leipsic 1 (1912) 512.

141. NELSON, JOHN B., and THEOBALD SMITH. Studies on a paratyphoid infection in guinea pigs. I. Report of a natural outbreak of paratyphoid in a guinea pig population. Journ. Exp. Med. 45 (1927) 353–364.

142. SMITH, THEOBALD, and J. B. NELSON. Studies on a paratyphoid infection in guinea pigs. II. Factors involved in the transition from epidemic to endemic phase. Journ. Exp. Med. 45 (1927) 365–378.

143. GILL, C. A. The Genesis of Epidemics. Wm. Wood & Co. New York (1928).

144. MACCALLUM, W. G. On the haemetozoan infection of birds. Journ. Exp. Med. 3 (1898) 117–136.

145. ROSS, R. Report on the cultivation of Proteosoma Labbé in the grey mosquito. Calcutta. Reprinted in the Ind. Med. Gaz. 33 (1898) 410.

146. WHITMORE, E. R. Observations on bird malaria and the pathogenesis of relapse in human malaria. Johns Hopkins Hosp. Bull. 29 (1918) 325.

147. SERGENT, ED. and ET. A vantages de la quininisation préventive demontrés et précises experimentalement (paludisme des oiseaux). Ann. Inst. Past. 35 (1921) 125–141.

148. ROEHL, W. Die Wirkung des Plasmochins auf die Vogelmalaria. Arch. f. Schiffs- u. Trop.-Hyg. 30 (1926) 11–18.

149. HARTMAN, E. Certain interrelations between P. praecox and its host. Am. Journ. Hyg. 7 (July, 1927) 407–432.

150. HUFF, C. G. The effects of selection upon susceptibility to bird malaria in Culex pipiens Linn. Ann. Trop. Med. & Parasit. No. 4 23 (December 31, 1929).

151. HARTMAN, E. Three species of bird malaria, P. praecox, P. cathemerium sp. nov., P. inconstans sp. nov. Archiv f. Protistekunde 60 (1) (December 2, 1927) 1–7.

152. HUFF, C. G. Personal communications.
153. HUFF, C. G. Studies on the infectivity of plasmodia of birds for mosquitoes with special reference to the problem of immunity in the mosquito. Am. Journ. Hyg. No. 6 7 (November, 1927) 706–734.
154. DANIELS, C. W. On the transmission of Proteosoma to birds by the mosquito. Roy. Soc. Rep. to the Mal. Com. Proc. Roy. Soc. London 44 (1899) 443–454.
155. JAMES, S. P. Malaria in India. Sc. Mem. by the Off. of the Med. Journ. San. Depts. of Gov. of India. New Series No. 2 (1902).
156. RUGE, R. Untersuchungen uber das deutsche Proteosoma. Centralbl. f. Bakt. 29 (1901) 187–191.
157. SERGENT, ED. and ET. Les hemalozoaires d'oiseaux. Ann. l'Inst. Past. 21 (1907) 251.
158. NEUMANN, R. O. Die Ubertragung von plasmodium praecox auf Kanarien vogel. Arch. f. Protist. 13 (1909) 23–69.
159. DARLING, S. T. Factors in the Transmission and prevention of malaria in the Canal Zone. Ann. Trop. Med. & Parasit. 4 (1910) 179–225.
160. PETERS, O. H. Epidemic Diarrhoea. Cambridge University Press (1911).

ILLUSTRATIONS

PLATE 1

Cage used in first experiment in Boston. (The front glass has been raised.)

PLATE 2

FIG. 1. Type of cage used in Manila; front view.
2. Type of cage used in Manila; end view.

TEXT FIGURES

FIG. 1. Chart 1, first experiment, epidemiology of avian malaria.
2. Chart 2, second experiment, epidemiology of avian malaria.
3. Chart 3, third experiment, epidemiology of avian malaria.

PLATE 1.

1

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PLATE 2.

BORED-HOLE LATRINE EQUIPMENT AND CONSTRUCTION [1]

By CLARK H. YEAGER

Of the International Health Division, Rockefeller Foundation

SEVEN PLATES AND FORTY-SIX TEXT FIGURES

In response to numerous requests for descriptions of latrine-boring equipment, where it may be purchased, the cost, and how to use it, this article has been prepared.

The selection of the locations for bored-hole latrines should be under the direction of a person who has been instructed as to the possibility of pollution of domestic water supplies, especially the contamination of nearby shallow wells. Until more scientific data are available, the installation of bored latrines is suggested only for areas in which there is no danger of infecting the drinking water.

Satisfactory boring equipment that is cheap enough for wide distribution in poor communities is not yet made by any of the manufacturers, but an inexpensive satisfactory auger can be made by purchasing an auger bottom, and making the shaft and turning handle locally.

According to requests there seems to be need for an auger costing about 20 dollars United States currency that can be used universally and will work in water, soft sand, mud, clay, sea shells, ashes, and rock. We have not yet found a cheap auger that will work everywhere, and it is not likely that a single cheap auger can be made that will work in all the different formations. However, to be of practical value in most places the boring equipment must be the cheapest that will do the work. Many of the elaborate machine-driven rotary drills used in the oil fields and in some mining operations are too expensive and are not practical for boring latrines. In many places 90 per cent of the boring is in sandy clay or similar material, and only 10 per cent in soft sand requiring valve tools

[1] This work was done with the support and under the auspices of the Government of the Philippine Islands and the International Health Division of the Rockefeller Foundation.

or in other formations in which more-expensive equipment is needed. In such places it is a waste of money to purchase the more-expensive augers for the entire area, when cheaper augers will do 90 per cent of the work just as well and frequently better because of the design of the auger.

In a previous article an auger was suggested that will bore satisfactorily in most places, but this auger was not designed to cut through rock or to work in quicksand. Complaints stating that the auger failed in laterite, adobe rock, and sand have been received. We would not select an auger made for wood boring to cut a hole in marble or steel, and the selection of an auger is just as important in earth boring. The selection of boring tools depends upon the geological formation into which the hole is to be made.

Much of the equipment to be described can be made locally. It would require several volumes to cover the manufacturers' descriptions of the boring equipment on the market. I have not seen all of the augers manufactured, and very likely there are good tools that have not come to my attention, but the material included in this article will be sufficient for a selection of supplies that will be useful in making bored-hole latrines in a variety of formations. Much description that would not add greatly to the value of the article has been omitted.

The size of the holes to be bored is important in selecting equipment. Bored-hole latrines have been made from 10 to 24 inches in diameter, but 14- and 16-inch holes have been most frequently bored. There are some advantages in boring the holes only 12 inches in diameter, although there is more danger from fouling the sides and the capacity is more limited. It has not definitely been determined whether or not the 12-inch holes give the soil bacteria a better chance to work on the contents than in the larger holes. If the soil is porous the 12-inch holes could be used several years, especially with the water trap discussed under Construction.

If the walls of the hole cave in, a lining is required and this reduces the diameter of the 12-inch holes to about 10 inches, which is too small for practical use. An advantage of the 12-inch hole is that it is easier to bore than a 16-inch hole, and lighter and less-expensive equipment can be used. In some areas in the Philippines the 16-inch holes have been filled two-thirds full within fifteen months because coconut husks, sticks, and leaves were thrown into the hole instead of water or paper. Twelve-inch holes in these places would be filled in less than

a year. In many countries 14-inch augers are used, but fouling has been reported and in some of these places they have now changed to 15- or 16-inch augers. However, the 14-inch holes are satisfactory in many countries, and in the Philippines we have installed many 14-inch latrines. If the soil is likely to cave in we usually use a 16-inch auger because the bamboo lining reduces the diameter of the latrine to about 14 inches. In letters from manufacturers larger holes have been recommended in order to allow a man to go down to remove stones when necessary, but the employees in the Straits Settlements, Philippine Islands, and other countries have no trouble in going down a 16-inch hole. Fortunately bowlders are seldom encountered, except in some areas.

A 14-inch latrine would have to be bored to a depth of about 26 feet to have the same capacity as a 16-inch latrine 20 feet deep.

We generally speak of boring 14- or 16-inch holes with augers of these diameters, but in most soils the augers actually cut the holes an inch or two larger in diameter than the size of the auger.

The depth of the bored-hole latrine is from 12 to 26 feet. We stop at 12 feet only when deeper boring is difficult and expensive. The holes should average about 19 feet in depth, although we have made a number of school and public latrines 23 feet deep.

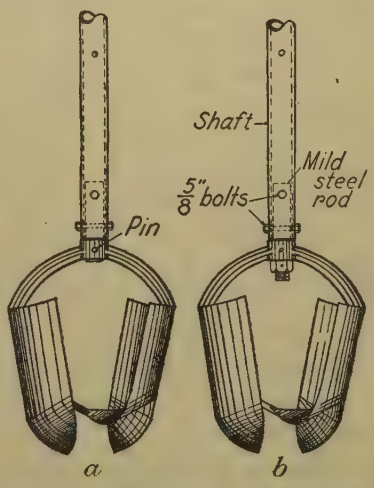


FIG. 1. The Iwan auger. *a*, Shaft attached to auger arch; *b*, a more solid joint with a nut below the socket. The bolts and nuts are not necessary if the shaft is welded to the arch.

THE IWAN POST-HOLE AUGER

The Iwan post-hole auger (fig. 1) is inexpensive and can be used for nearly all surface-soil borings where hardpan, rock, and quicksand are not encountered. The shaft of this auger supplied by the manufacturer is not as satisfactory as the shafts made locally; so we purchase only the "auger bottoms," as the manufacturer calls them, and make our own shafts. The auger bottoms consist of two cutting blades and an arch or

yoke to which the blades are riveted and to which the shaft can be attached. In order to save cost of transportation one shipment of auger blades and arches were ordered unassembled. We had the blades and arches welded and riveted together locally and the augers worked very well, but we did not save much money and had the additional trouble and loss of time. In following orders we always ordered the "auger bottoms" as advised by the manufacturer and not the blades and arches. The blades must be riveted in proper alignment or the auger will not bore a straight hole. Because of easier packing in standard cases we now order in lots of even dozens and not ten, sixteen, or thirty-eight auger bottoms for one shipment. The bottoms 16 inches in diameter cost 81.60 dollars United States currency a dozen. The 14-inch bottoms cost 67.20 dollars a dozen.

We have broken only two of the 1/8-inch blades on the standard Iwan augers in the Philippines; therefore, for general distribution we do not find the additional cost of heavier blades justified, but Dr. John F. Kendrick, in India, has not been so fortunate, and purchases especially heavy blades and makes the arches (yoke pieces) and shafts locally. Unusual soils require the heavy blades. Iwan Brothers, of South Bend, Indiana, make extra heavy 16-inch diameter auger blades of 3/16-inch steel in lots of ten pairs at 6 dollars United States currency per pair, f. o. b. cars, New York. The steel strap to bring the blade points together at the bottom is furnished by the manufacturer. The auger bottom, complete with arch and heavy blades riveted together, costs 12 dollars. The standard weight 16-inch augers cost 7.50 dollars each. The regular 14-inch augers cost 5.95 dollars each, and according to Mr. Rollin C. Dean, of the Rockefeller Foundation, the 14-inch augers with 3/16-inch blades would cost about 10.50 dollars each.

The shaft.—The 1-inch shaft supplied by the manufacturers of the Iwan augers is in short sections and has threaded joints. This type of shaft is satisfactory for the purpose originally intended as a post-hole auger, but for boring to a depth of about 19 feet a $1\frac{1}{2}$-inch shaft from 19 to 22 feet long is more satisfactory.

The auger bottom measures 19 inches from the tip of the blades to the top of the arch; therefore, a 20-foot shaft allows boring to a depth of about 20 feet. We usually use ordinary

water or gas pipe, plain or galvanized, which is shipped in lengths averaging over 19 feet. The longest lengths are selected because the auger is more easily turned if at least 2 feet of the shaft extends above the surface of the earth when the last few turns are being made.

In soft soil 1¼-inch pipe (inside diameter) for making shafts has given satisfactory service, but in most of the soil in the Philippine Islands it has been necessary to use 1½-inch pipe, and in one place in the Straits Settlements 2-inch steam pipe was used. In early trials the 1-inch and 1¼-inch shafts bent and broke, and a number of braces designed to keep the shaft from bending and boring at an angle were tried. These devices worked very well, but added to the expense, complicated the equipment, and required more time on account of lost motion in adjusting the shaft. Then shafts of larger diameter were used, and by selecting shafts large enough to suit the soil there was no further difficulty. Shafts that do not bend too much will bore straight holes unless a bowlder or other solid material causes deviation. A large shaft has a more even torque than a small one and will not break or bend enough to bore at an angle. Two- or 3-inch shafts can be used, but in most hard soil 1½-inch pipe serves the purpose.

In places where the ordinary 1¼-inch water-pipe shafts broke, steam pipe and boiler tubes were tried and not only extra thick but double extra heavy pipe was used, but these heavy pipes are usually not as satisfactory, considering cost and service rendered, as ordinary pipe of larger diameter. The strength for the money expended up to certain limits depends upon the diameter of the shaft. The torque of an ordinary 1½-inch water-pipe shaft is very much better than that of a solid bar or a smaller pipe of the same length and weight. In some countries the water pipe is of inferior quality and at times crushes or splits up the seam; in these instances, after the failure of 2-, 2½-, or 3-inch shafts, it might be necessary to use heavy or extra-heavy steam pipe.

The shaft auger-bottom joint.—The threaded shafts of the Iwan augers as supplied by the manufacturer are screwed into a socket in the auger arch. These are probably satisfactory for boring shallow holes for telegraph poles, but are not strong enough for most bored-hole latrine boring. A more satisfactory joint is shown in fig. 1, *a*. This joint is made by threading the

end of a piece of round bar steel and screwing the bar into the auger socket. A hole is drilled through the socket and bar and a tool-steel pin is inserted for additional strength. A bar 10 inches long and 1½ inches in diameter is suitable for a 1½-inch shaft. The shaft is fastened to the bar with two ⅝-inch bolts or steel rivets, which are inserted through holes bored 4 inches apart in opposite directions through the shaft and bar. These joints are satisfactory in most soils, but we have broken the socket pins in four augers and twisted the auger bottom off in one instance. After repairing we had no further trouble. Since losing one twisted auger bottom under 18 feet of water we have had the joints made stronger by screwing a nut on the bar which extends through the socket in the arch (fig. 1, *b*). We have had only one socket pin break in forty-eight augers since using the nut and in this instance the shaft revolved freely in the socket, but the nut on the underside stopped the auger bottom from coming off. The auger struck rock and was suddenly stopped. The blades of the auger were bent, which shows the strength of the joint. In the Straits Settlements in one area we bolted iron plates to the shaft and arch to take the strain off the socket, but at that time we did not use the extra nut.

We are now making the joint by welding the socket, bar, and shaft together at a cost of 8 pesos less per auger than the cost of boring the holes and using bolts, pins, and the nut. We have never had a welded joint break.

Turning the auger.—A simple and cheap way to turn the auger is to hitch a rope around the shaft and use a bar of wood or metal as a lever, but in our experience we find turning handles designed for the purpose are more satisfactory. The Wilson wrench, one of the best on the market and commonly used by oil drillers, is an excellent device for turning, but these wrenches are comparatively expensive. A more satisfactory wrench for latrine boring and used by us in the Straits Settlements and the Philippine Islands costs 7.50 dollars complete and has many advantages. This wrench is made by bolting a handle made locally by a blacksmith to a 2½-inch Vulcan bijaw or similar chain tong usually carried in stock by hardware dealers. The additional handle greatly facilitates turning, and by slipping a 4-foot length of pipe over each handle the leverage is greatly increased. This wrench can be readjusted to any position on the shaft without removing the chain, by a quarter

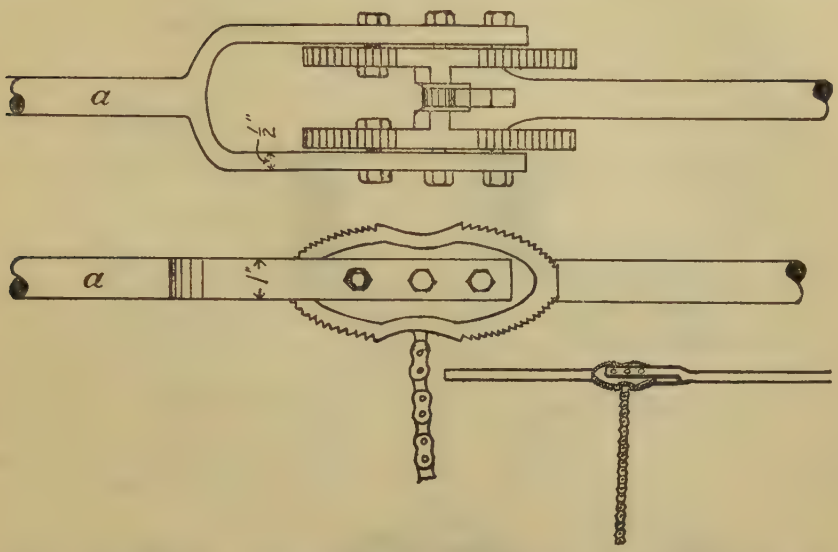


FIG. 2. The chain-tong turning handle, made by attaching the handle *a* to a Vulcan bijaw chain tong. This is an excellent turning device and has been used in many places.

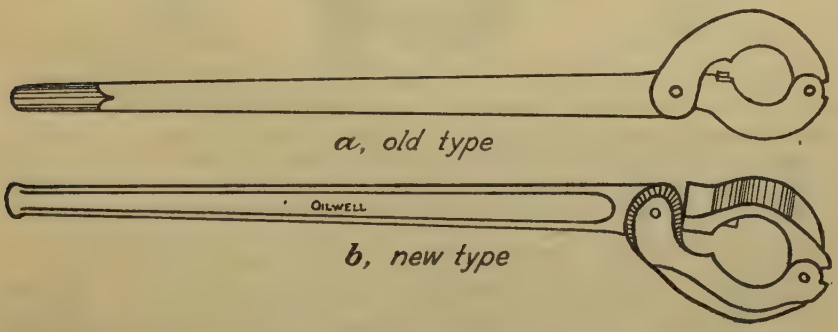


FIG. 3. Crumbie tongs, one of the most satisfactory inexpensive tongs on the market. *a*, Old type; *b*, improved Crumbie tongs; these cost a little more, but are worth it.

reverse turn and sliding the wrench up or down. Fig. 2 shows the simple construction of this wrench.

One of the most satisfactory and inexpensive wrenches is the Crumbie or the improved Crumbie wrench shown in fig. 3. This wrench does not damage the shaft and costs only about 3.50 dollars United States currency. An extension handle similar to the one shown on the Vulcan bijaw greatly improves the use of this wrench for boring. The National Supply Company and many other dealers carry these wrenches and the Vulcan bijaw in stock.

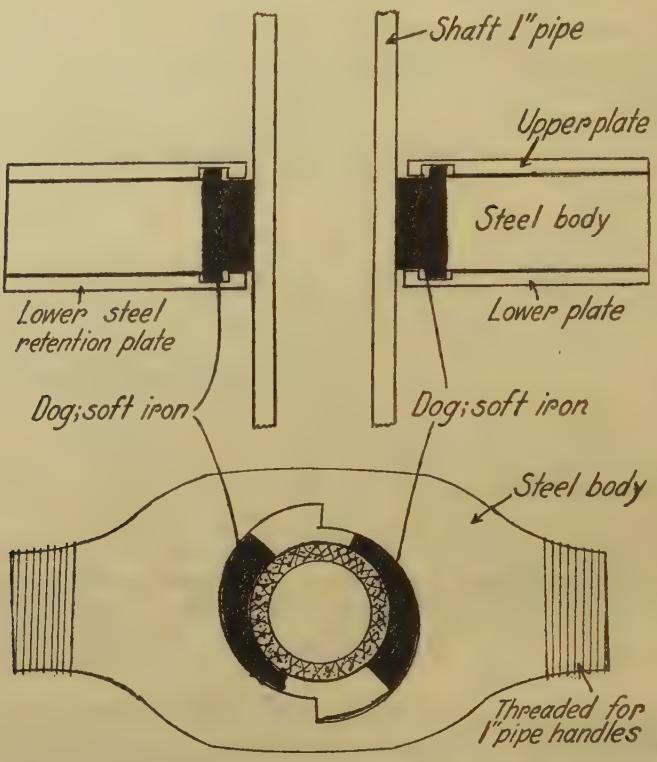


FIG. 4. Turning handle designed by Doctor Hamilton. "The two steel retention plates with the grooves on their inner surfaces serve to prevent the dogs from falling out of place when no pipe is between them. The plates are bolted together and to the frame of the body so that the dogs are easily removable and exchanged when worn or damaged."

Another wrench, shown in fig. 4, was designed by Dr. A. H. Hamilton in Java. He has this wrench made locally, but the cost, 40 pesos in the Philippines, is too high for general use.

Pipe-cross turning handles.—For economy and simplicity we designed the turning handles shown in fig. 5, *a*. We first used these handles in the Straits Settlements, and since making minor improvements we are using them on most of the augers in the Philippines. These handles are easy to assemble and can be made easily. A cross joint, or four-way water-pipe joint as it is sometimes called, large enough to slide up and down the shaft, two 4-foot pieces of pipe, and a $\frac{5}{8}$-inch chrome or tool-steel pin are all the parts needed. Since breaking a few of the light-weight crosses usually used for water pipe, we use heavier steam-pipe crosses. A hole is drilled through the center of the cross, through which the $\frac{5}{8}$-inch tool-steel pin can be

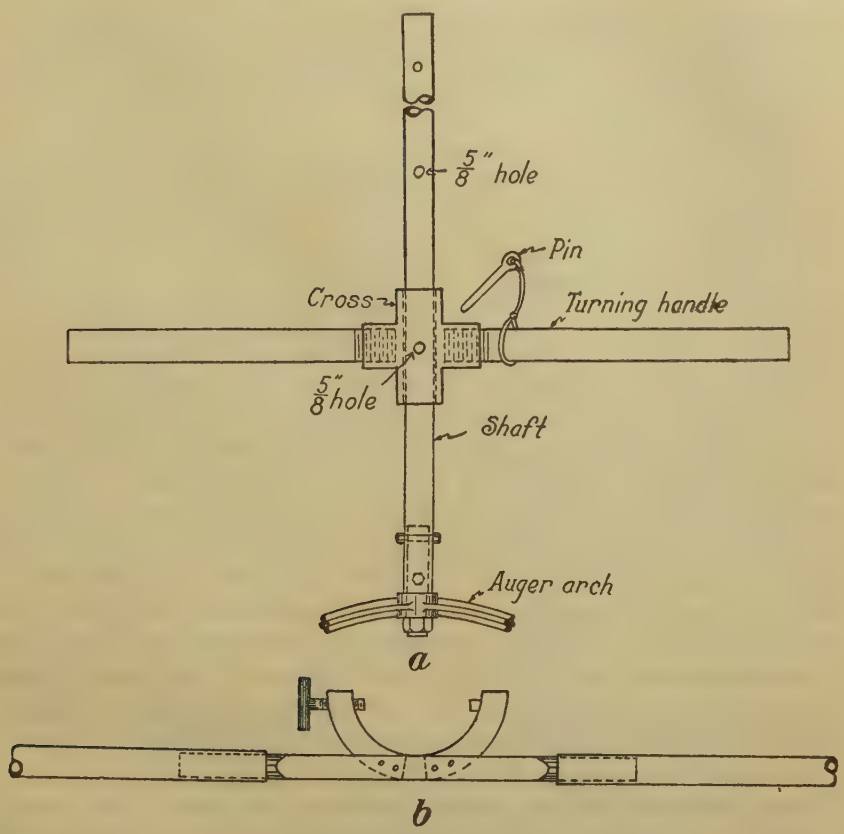


FIG. 5. Turning handles. *a*, The pipe-cross turning handle. This outfit is usually used in the Philippine Islands for general distribution because it is the least expensive satisfactory device we have tried. The only materials required are two pieces of pipe, a heavy cross or four-way joint and a tool-steel pin to transfix the cross and shaft. The cross slides easily up or down the shaft; *b*, a turning handle for use on a shaft drilled with holes to engage the lugs. This wrench is more expensive than the pipe-cross handle.

inserted. At times we ream out the cross to make it slide easily on the shaft. The shaft is drilled at 18-inch or 2-foot intervals so that the position of the cross can be changed when necessary. The two 4-foot pipes are screwed into the cross on opposite sides of the shaft and serve as levers for turning the auger.

The cost of this cross turning handle depends upon the cost of material and labor. In Manila the auger shaft drilled and welded to the auger bottom and the cross turning handle, complete with pin ready for use, costs 17.50 pesos delivered to our

storeroom. Another handle is shown in fig. 5, *b*. This handle hooks in a hole in one side of the shaft and a screw enters a hole on the opposite side. This handle costs double the price of the cross handle.

The coupled shaft.—Where the transportation of the 20-foot shaft is difficult, a coupled shaft made of two 11- or 12-foot pipes can be used. A strong joint that will not wabble can be made by riveting a round solid iron bar 12 inches long into the end of one section of the shaft, allowing 6 inches of the bar to extend out of the end as shown in fig. 6, *a*. The protruding bar and the end of the other section of the shaft can be drilled in opposite directions for the insertion of two $\frac{5}{8}$-inch bolts, which can be removed when transporting the auger. If only one cross turning handle is used the upper section of the shaft will have to be added every time a latrine reaches a depth of about 11 feet. This takes only a minute, but if a number of latrines are to be bored in one area it saves time to have two crosses, one below the bolts and one above the bolts on the shaft. The 4-foot handles can be unscrewed from the lower cross and screwed into the upper cross by hand when necessary to shift to the upper section of the shaft. Each cross allows the handles to be shifted 11 feet. Another method is to bolt six crosses permanently to the shaft at 3-foot intervals, then the handles can be screwed in each cross as the boring becomes deeper, without shifting the cross. Our workmen prefer shifting the cross, and six crosses increase the cost; therefore, we use only one or two crosses.

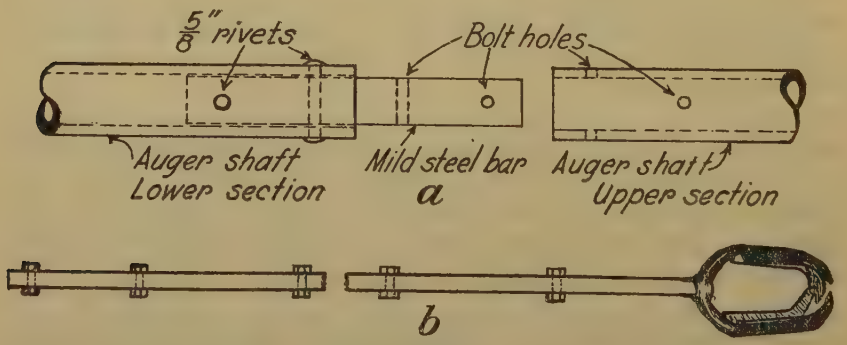


FIG. 6. Coupling and shaft. *a*, A solid coupling for shafts made in sections; two bolts are removed to take the shaft apart; *b*, the bolt shaft, one of the most useful shafts we have used. This shaft stands more rough use than any other shaft tried. Permanent bolts or rivets transfix the shaft at 3-foot intervals. The turning handles never damage this shaft. The bolt heads act as lugs for the handles to push against.

The bolt shaft and turning handles.—This method of turning is simple to use, fool proof, and easy to make. The bolt shaft shown in fig. 6, *b*, is made by inserting a series of pins or bolts through the shaft at 2-foot intervals, allowing the head of the bolt and nut to serve as lugs. If the bolts are too long cut them off flush with the nut. The nuts on the bolts are screwed against the shaft tightly and are never removed. The heads of the bolts and the nuts serve as lugs for the turning handle to push against to prevent the handle slipping around the shaft, and does away with the use of expensive chain tongs and wrenches, which damage the shaft to some extent. The turning handle is made from an iron bar, which is shaped so that it will hook on the nut on one side of the shaft and push on the bolt head on the opposite side and can be quickly attached for turning. Two different turning handles are shown in fig. 7, *a* and *b*. This device is a great time saver as there are no clamps, chains, screws, pins, or ropes to adjust. In one instance the shaft of an auger equipped with the cross turning

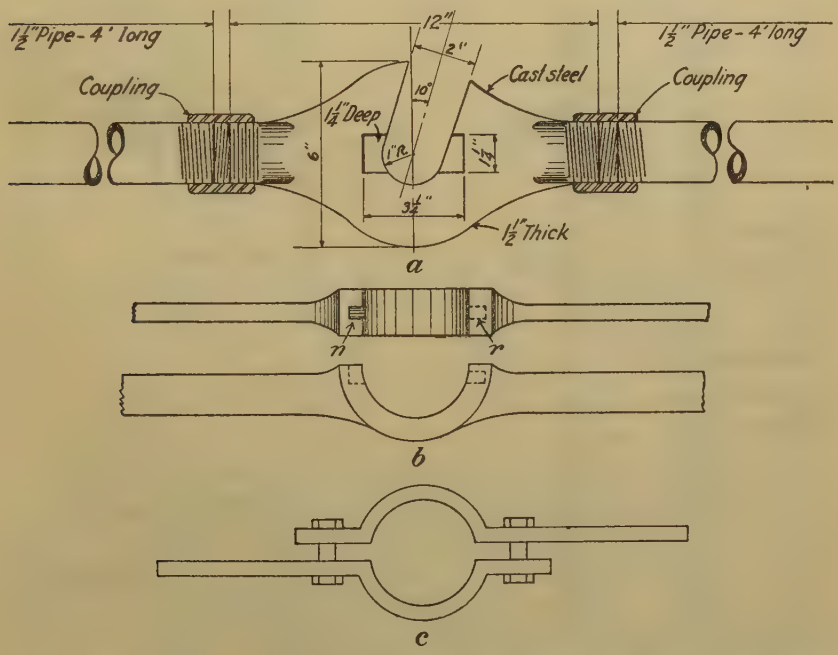


FIG. 7. Turning handles. *a*, One type of locally made turning handle for the bolt shaft, hammered out by a blacksmith. These can also be made of cast iron; *b*, another type of locally made handle for the bolt shaft. The head of a bolt on the shaft enters the socket *r*, and the nut on the opposite end fits into notch *n*; *c*, a turning handle that can be made locally or purchased ready-made from dealers.

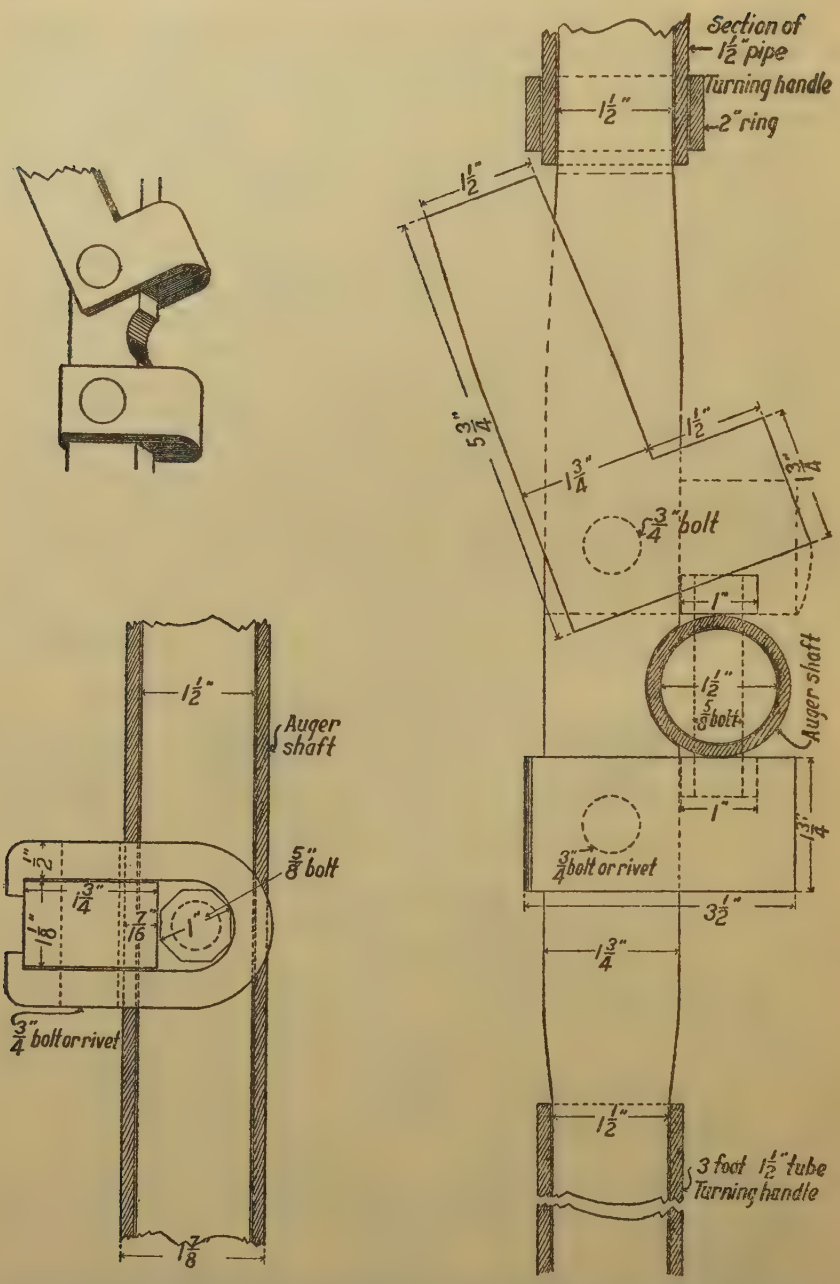


FIG. 8. A more elaborate turning handle for use on the bolt shaft. This is an excellent handle but costs 20 pesos to make locally. In large quantities the cost would be less.

handle was damaged so that the cross would not slide up the shaft, but the permanently bolted shaft stands a great deal of damage before it is put out of use. If the projecting bolts are objectionable, one bolt can be used and shifted from hole to hole when necessary to change the position of the handle. The series of permanent bolts are suggested in order to save time. The handle shown in fig. 7, *c*, is useful if rivets are used instead of bolts to prevent slipping. A more elaborate wrench, shown in fig. 8, has no damaging teeth and can be made locally. There are many excellent ready-made wrenches that can be purchased from dealers, but these are more expensive.

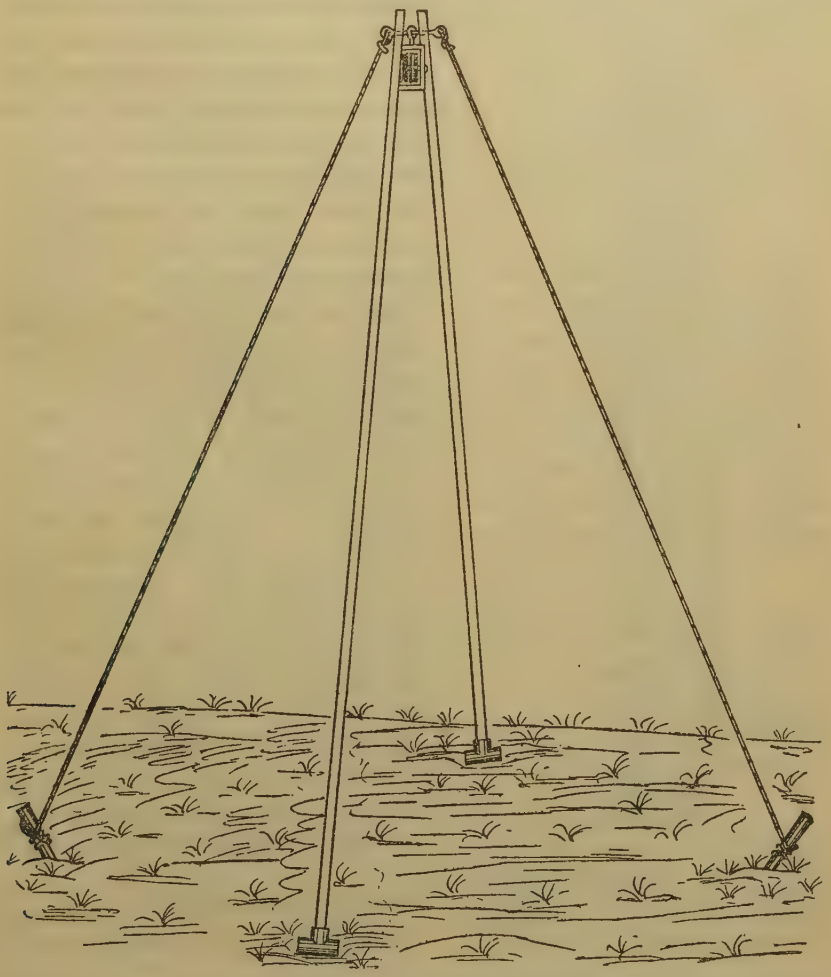


FIG. 9. The A frame now used instead of a tripod for hoisting augers. The guy ropes are usually tied to a house, tree, or fence post. Bamboo is usually used because it is much cheaper in the Philippines than iron pipe.

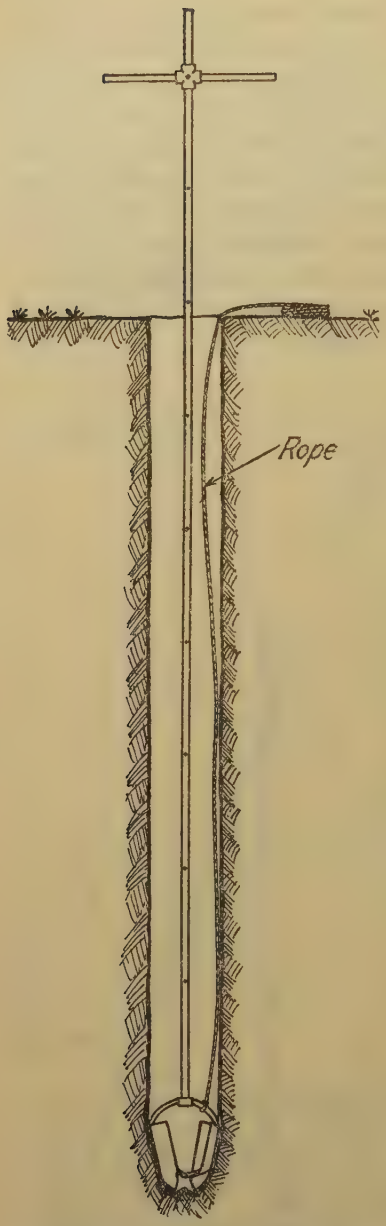


FIG. 10. In some places augers are lifted by direct pull, but the job is too heavy in most areas. The rope is attached to the arch or low down on the shaft.

HOISTING DEVICES

Tripods.—A tripod 25 feet in length made of bamboo or other wood or 2-inch water pipe is very useful for hoisting the auger by means of a pulley and rope.

Inverted V- or A-shaped frames.—For the past two years we have discontinued the use of tripods and now use only two poles or pipes supported by two guy ropes (fig. 9). The A frame is easier to transport and erect than a tripod and can be put up in places where there is not enough space for a tripod. The guy ropes can be attached to a house, trees, posts, or stakes driven into the earth. In some localities we get the bamboo poles for nothing, and in other places the bamboo costs 3 pesos or more. Bamboo breaks after using it a few times, and in places where it cannot be obtained or is expensive we make an inverted V frame from two $1\frac{1}{2}$-or 2-inch pipes fastened at the top with an iron bolt. The feet of this A frame are two T joints screwed on the ends of the legs. The T joints prevent the ends of the pipe from sinking into the earth. A stick or bar can be inserted into the T to prevent sinking in very soft soil.

Pulleys.—We have used a number of 12-inch well pulleys or gin

blocks for hoisting, but now use 4- to 7-inch compound pulleys of wood or metal. We usually use a double 6-inch pulley at the top of the frame and a single 4- or 6-inch pulley to attach to the auger. Compound pulleys are so well known that a description is not needed in this article.

If the soil and auger is not too heavy a tripod or hoisting frame is not necessary and the auger can be lifted by a direct pull on the rope attached to the arch of the auger as shown in fig. 10. It is difficult to start lifting an auger full of earth, but when once loosened it is easy to pull to the surface. The initial lift can be done by direct pull on the turning levers or by placing a plank or two across the mouth of the hole and applying leverage. Planks can be placed across the mouth of the hole and be notched so that they will support the shaft while turning.

The direct-pull method is too heavy in most areas in the Philippines, where we have even stopped using single pulleys and use compound pulleys. Dr. John L. Hydrick states that the direct-pull method is used successfully in Java and there is no tripod to transport.

Shaft support.—Latrines can be bored with only an auger, pulleys, and a tripod, but there is a great saving of energy if some kind of brace is used for the shaft of the auger. The most satisfactory cheap support we have used is a pair of doors, which cost 3 dollars United States currency, including material and labor. The doors are put in place as soon as the latrine is bored to a depth of about 2 feet. The doors are closed over the hole when the auger is lowered, and opened when the auger is raised. The doors are hinged to a wooden frame about 36 inches square, and the shaft of the auger turns in a hole cut in the closing edges of the doors (fig. 11).

Another type of brace that is cheap and satisfactory is shown in fig. 12, *a*. This brace is fastened to the frame about 5½ feet above the surface of the earth. A tipping auger can be lifted and emptied into a receptacle over the latrine, or a knock on the clamp of the brace will release the shaft, allowing the auger to be swung away from the hole to be emptied.

An excellent brace designed by Doctor Hamilton in Java is shown in fig. 13. This brace should hold the shaft steady, but the cost of making is too great for general distribution in the Philippines.

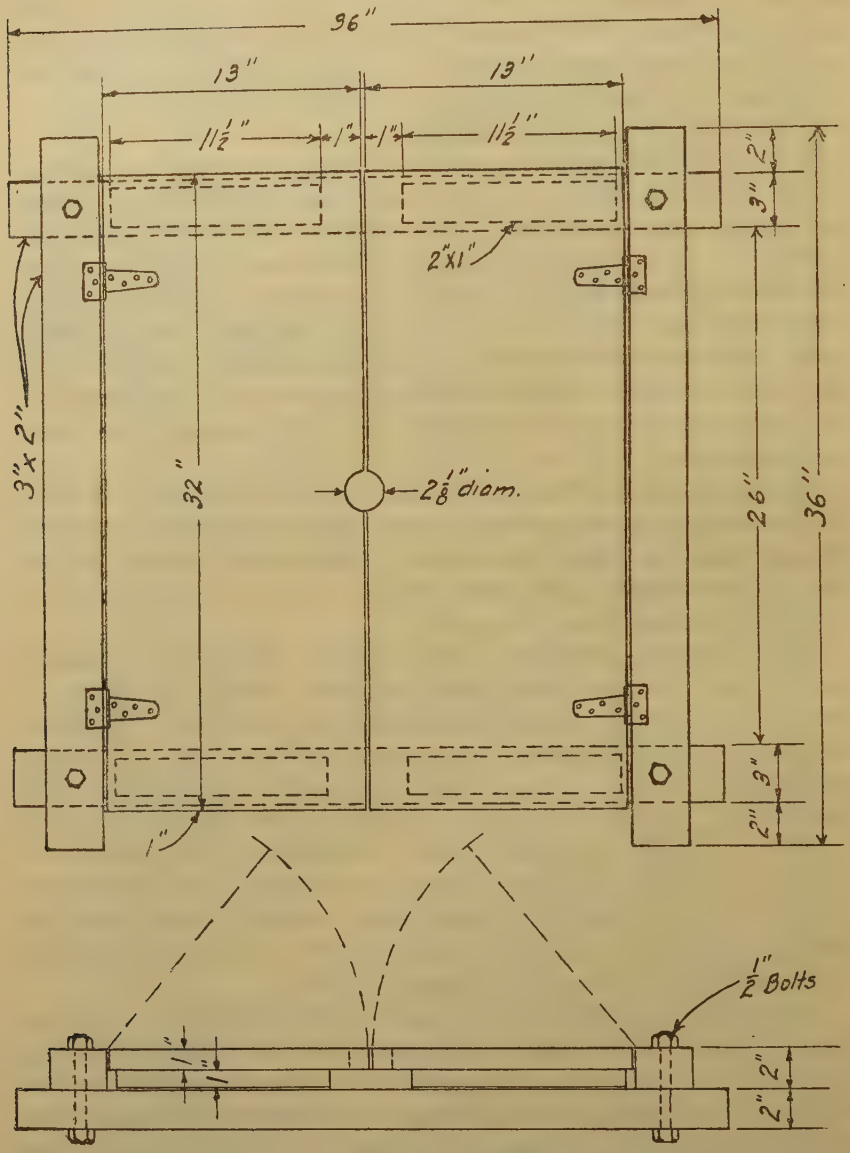


FIG. 11. Trap doors costing 6 pesos greatly facilitate boring. The auger shaft is supported by the doors when closed. Stakes can be driven into the earth at the notched corners to prevent movement of the platform while turning. One of these platform braces is now included as standard equipment with every auger used in the Philippines.

A quadruple brace sold by the Alsdorf Corporation is shown in fig. 14.

Accessories.—A bamboo pole or tamping rod is used in some kinds of soil, especially certain kinds of sands, to tamp the earth

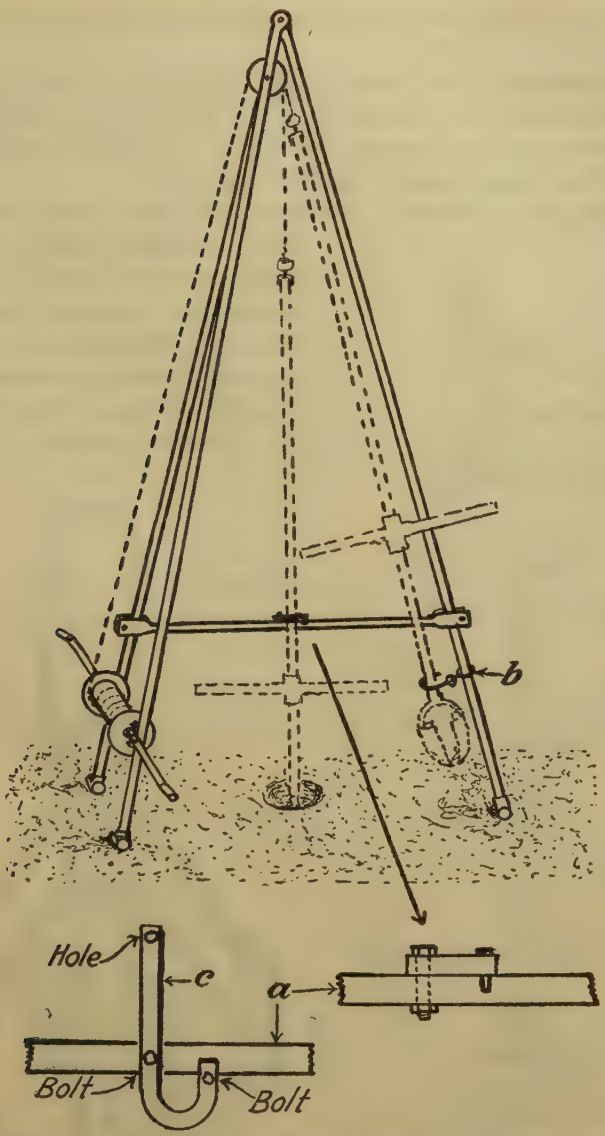


FIG. 12. This tripod is more difficult to transport than the A frames, but if properly made greatly speeds up boring when several holes are to be bored within a small area. *a*, Shaft support. A knock on the extension lever *c* releases the auger so that it can be swung away to be emptied; *b*, an iron hook that is a great time and energy saver. These hooks hold the auger away from the latrine while being emptied. The hooks are also used on A frames.

more solidly in the auger to prevent it from falling out when lifted. A little clay can be thrown down the hole in some places to make the earth more cohesive. Clay is sometimes used in

well drilling in very soft earth to prevent temporarily the sides from caving.

A long piece of 1- or 1¼-inch iron pipe with a tool-steel chisel riveted or welded into one end is useful for breaking hard strata or straightening the sides of the hole. Ordinary straight chisels, the T, or cross chisels, can be used.

An inexpensive swivel to prevent the ropes twisting can be used on top of the auger shaft, but this requires a high A frame. A swivel that will screw on the end of the shaft is made from an ordinary cap and iron ring as shown in fig. 15. Even a 15-foot A frame

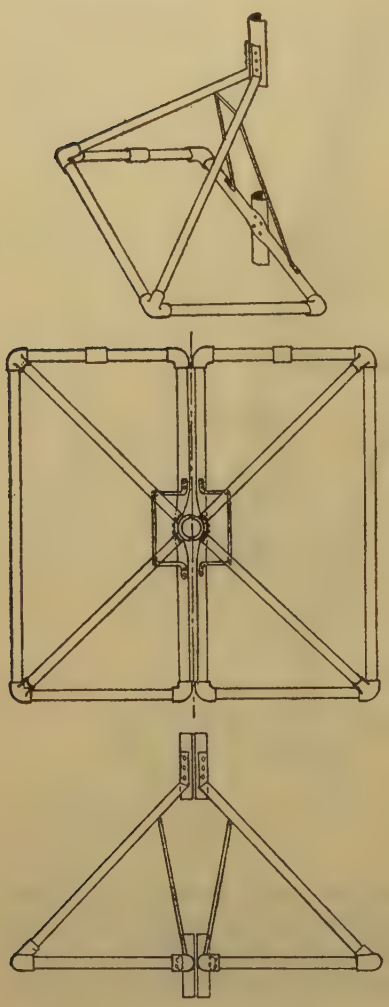


FIG. 13. An excellent shaft brace designed by Doctor Hamilton. The cost of production is a disadvantage of this device. (Drawing from Doctor Hamilton's sketch.)

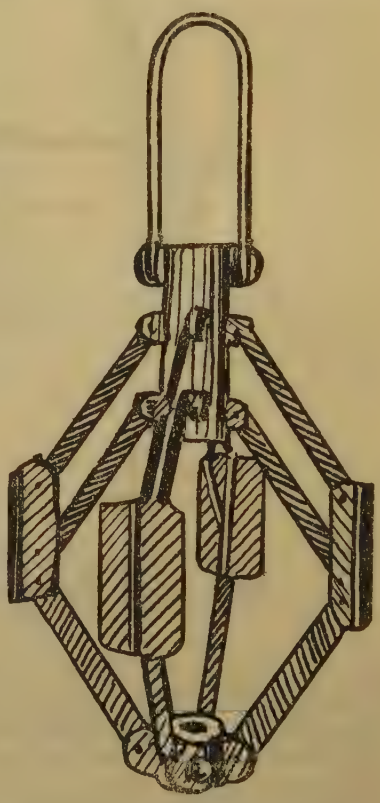


FIG. 14. A quadruple expansion brace sold by the Alsdorf Corporation. The stock size is made to fit the Standard earth auger.

can be used, if a removable turning handle is used and no swivel, by hooking the lower pulley of the tackle to a movable iron ring on the shaft. We usually use a 25-foot A frame for greater convenience, and on augers equipped with the cross turning handles, which are not removed when hoisting, we provide an iron ring that can be shifted and costs 40 cents at a ship chandlery or hardware store. The bolt of this ring is slipped into one of the easily reached holes of the shaft, and the tackle is hooked on each time before lifting. It is unhooked when turning the auger to prevent twisting. Devices for hooking the tackle to the shaft are shown in fig. 16.

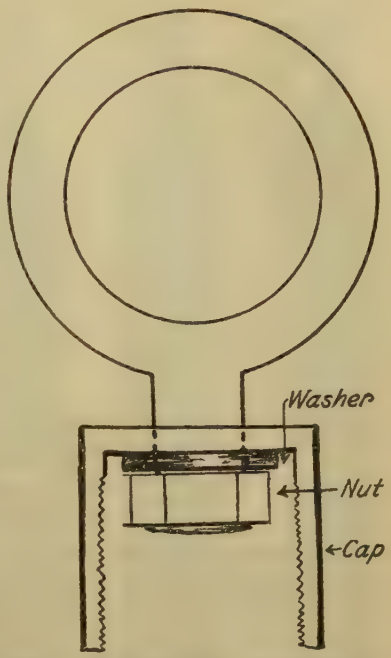


FIG. 15. A locally made swivel for use on the top of the shaft. We have used these swivels but prefer unhooking the rope from the shaft while turning the auger.

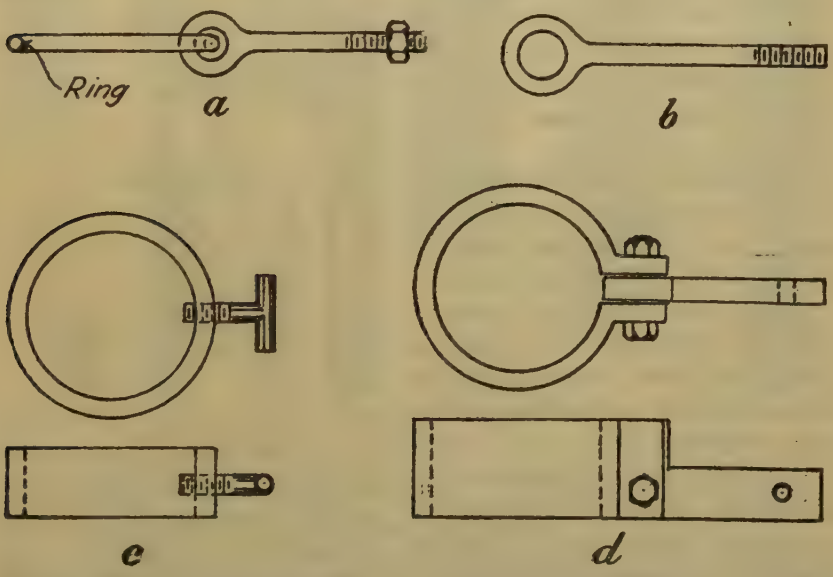


FIG. 16. Devices which can be attached to the auger shaft and adjusted to any position so that a hook on the hoisting rope can be quickly hooked on instead of tying and undoing knots; *a* and *b* are used on shafts with holes drilled at intervals such as used with the pipe-cross handles; *c* and *d* are used on the plain or bolt shafts.

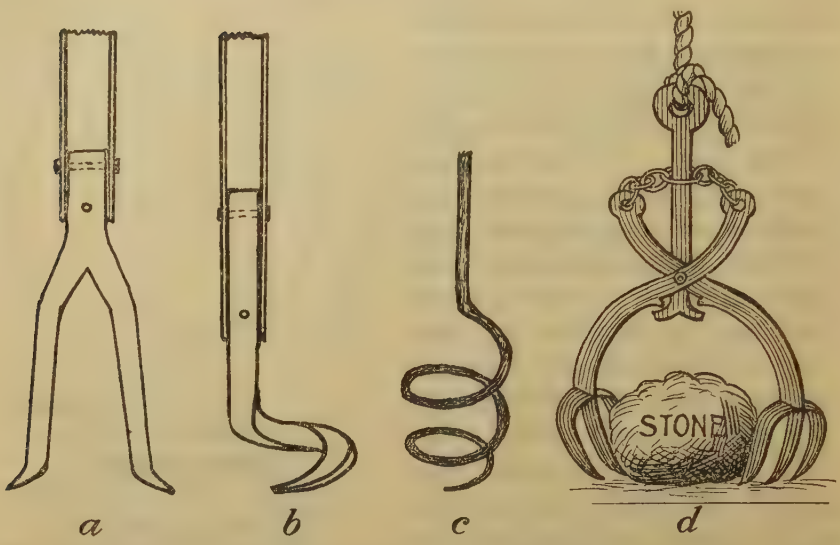


FIG. 17. Reamer, stone hooks, and grapple. *a*, An undercutting reamer which is useful in cutting away the sides of latrines below linings; fortunately it is rarely necessary to use one of these; *b* and *c*, stone hooks which are useful in removing small bowlders; *d*, a grapple (redrawn from picture from R. R. Howell & Co.).

We find an iron hook (fig. 12, *b*) attached to a leg of the A frame very useful to hold the auger away from the latrine when emptying. This saves energy because a man does not have to hold the auger for another man to empty.

The stone hooks and grapple shown in fig. 17, *b*, *c*, and *d*, are useful for hooking and pulling large stones out of the latrine.

The undercutter or reamer (fig. 17, *a*) is useful for cutting away the sides of the latrines below linings to facilitate sinking cylinders.

A cheap boring equipment for regularly hired squads.—The apparatus shown in fig. 12, while probably too expensive for general distribution, greatly facilitates rapid boring for the use

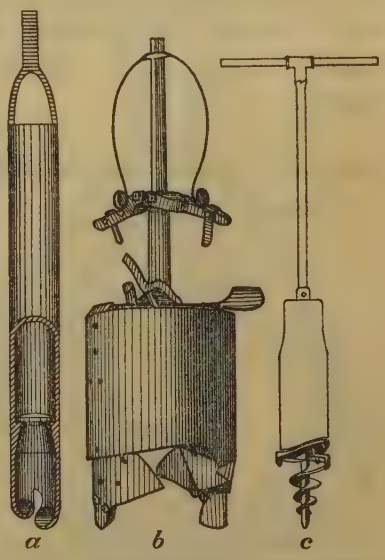


FIG. 18. Augers suitable for soft mud and silting sand. *a*, Type made by many manufacturers of drilling equipment; *b*, a heavy dumping auger such as used with machine-driven outfits; this auger is made by the Gus Pech Co.; *c*, the Lang auger with sand-boring screw; this is a good hand auger for boring in sand. See fig. 31, Howell drop-bottom auger.

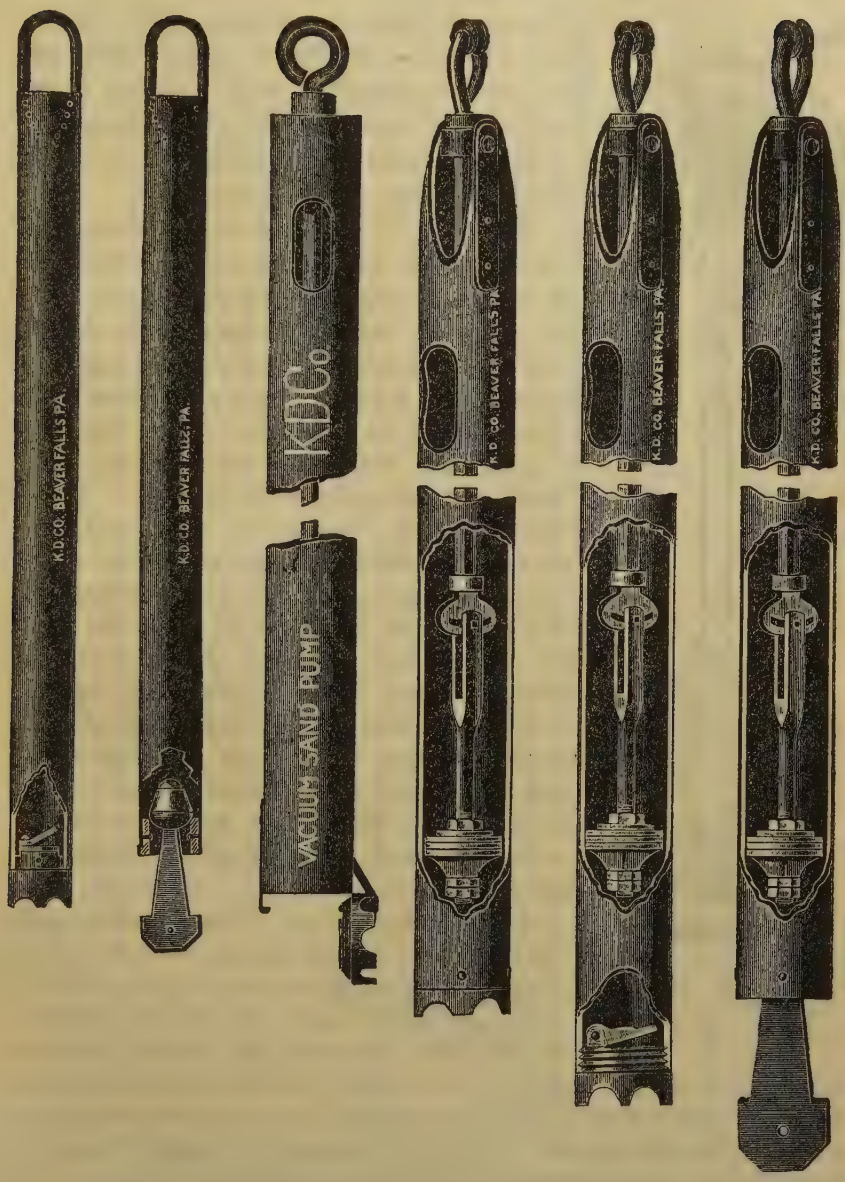

K.D. CO. BEAVER FALLS PA.
K.D. CO. BEAVER FALLS, PA.
KDCo
VACUUM SAND PUMP
K.D. CO. BEAVER FALLS PA.
K.D. CO. BEAVER FALLS PA.
K.D. CO. BEAVER FALLS PA.

FIG. 19. Sand pumps and bailers which can be purchased from dealers. These pictures are from the Keystone Drilling Co., Beaver Falls, Pa.

of a squad of regularly hired men. Four men can work faster with this outfit than any other equipment we know of at the price. It will be noted that two legs of the tripod are close together to allow use in limited space, and to furnish extra support where there is the greatest strain. The tripod is made

FIG. 20. The Iwan post-hole auger fitted with valves for use in silting sand.

locally of 2-inch water pipe. The cost of the equipment in Manila is 54 dollars for the tripod complete with winding drum and auger brace, not including the auger. This apparatus is more difficult to transport than the A-frame outfits.

Boring soft sand and mud.—These materials can be forced out with a pump, but it is not as satisfactory in routine work as an auger especially designed to do the work. A number of excellent sand bailers and augers sold by dealers are shown in figs. 18 and 19. Some of these work by a pounding motion, percussion, or spudding, and others work by rotation. Those shown in fig. 19 are not very useful in latrine installation. An excellent cheap rotating sand auger can be made by adding valves, or what might be called trap doors, to the ordinary Iwan post-hole auger. These doors are shown in fig. 20. Soft sand falls out of the sides of this auger as sent out by the manufacturer, but a piece of sheet metal hinged to the noncutting sides of this auger so that it will open about 2 inches, allowing sand to enter but not to fall out, serves the purpose in some places. Exceptionally soft sand will fall out of the bottom even when fitted with side valves, and in these places two additional doors should be fastened to the blunt edges of the blades crossing the bottom of the auger. The auger altered in this fashion does the work but is not as satisfactory as augers especially designed for silting soil. In order to empty this auger the shaft must be lowered almost horizontally, or a tipping hinge on the shaft can be made like those shown in figs. 21 to 23, which are made locally for use in the Philippines. These hinges always stop on a dead center, allowing the locking pin to be inserted quickly. A tap with a hammer or block of wood knocks the pin out when necessary. To facilitate transportation the

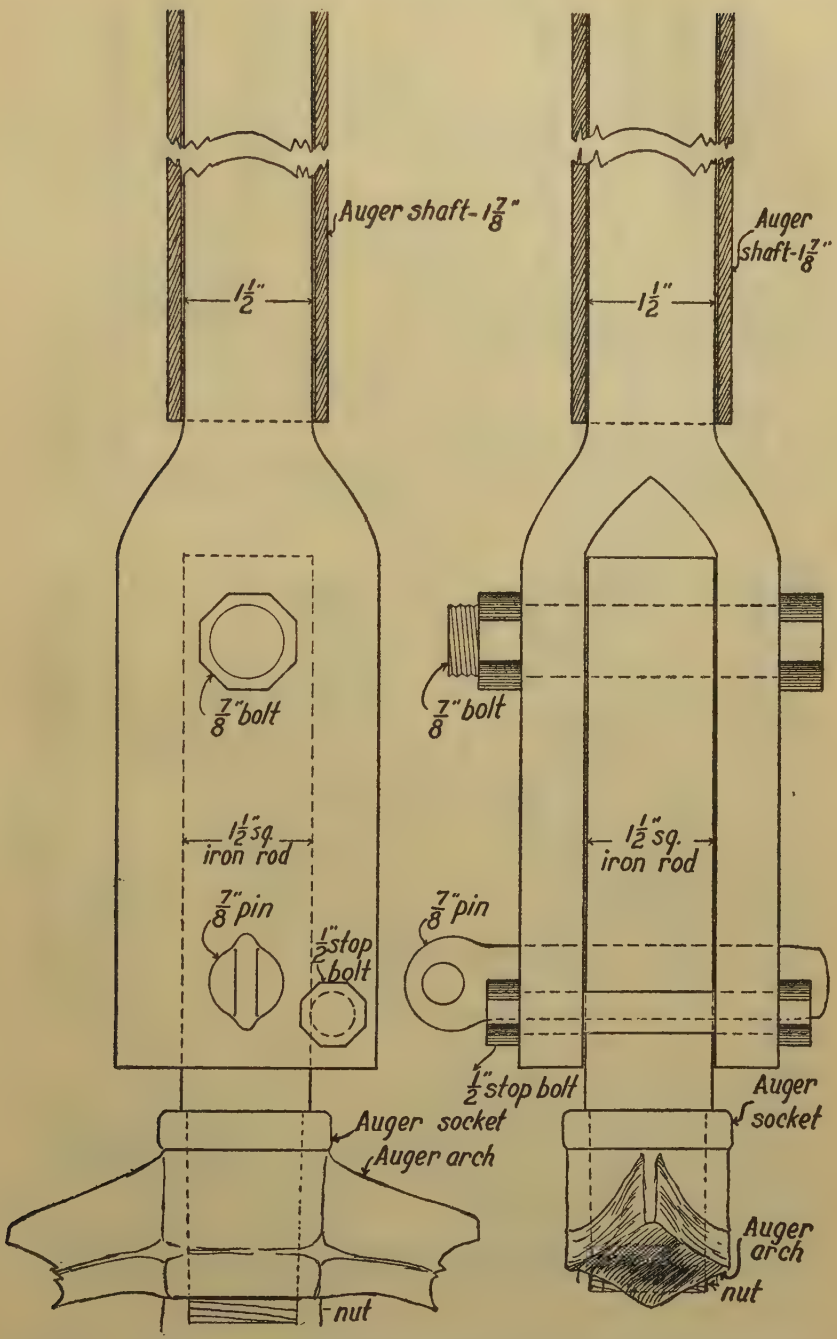


FIG. 21. A hinge to facilitate turning an auger over so that it can be dumped.

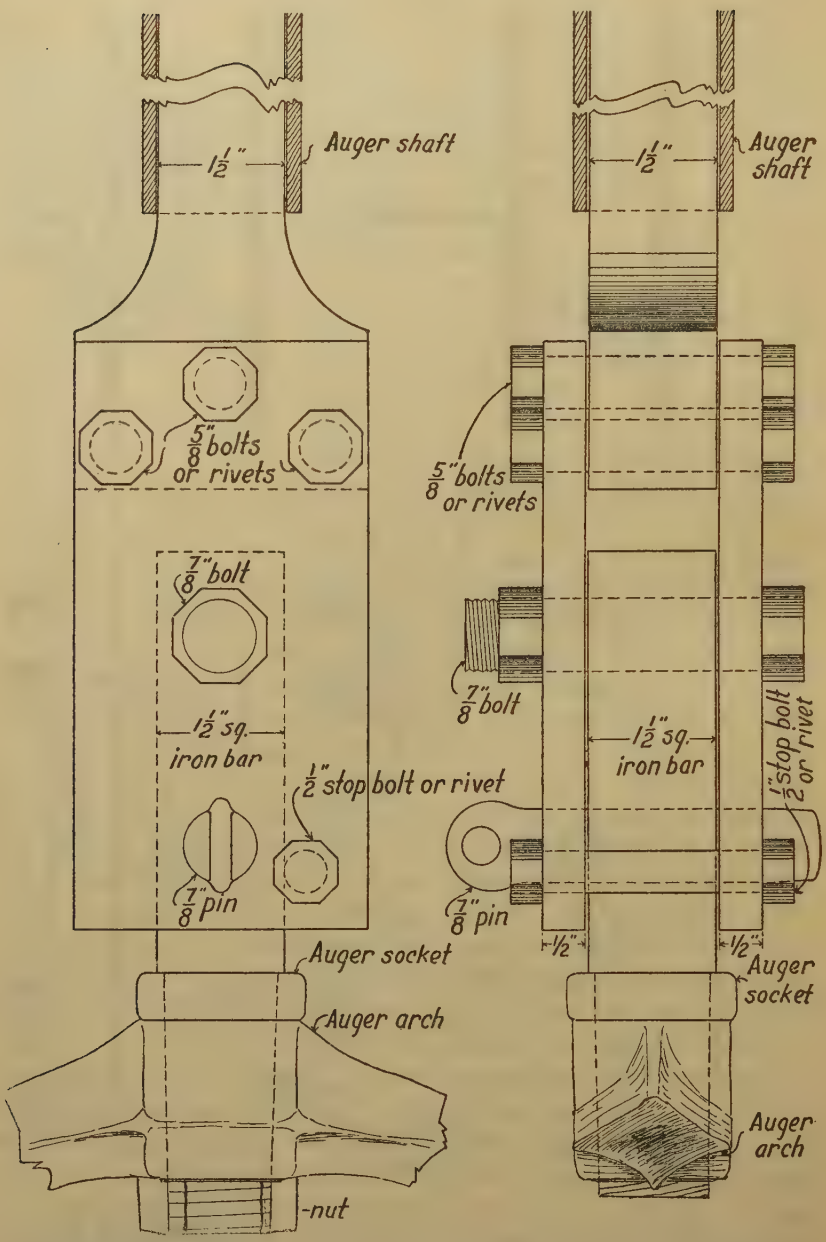


FIG. 22. A hinge to facilitate turning an auger over so that it can be dumped.

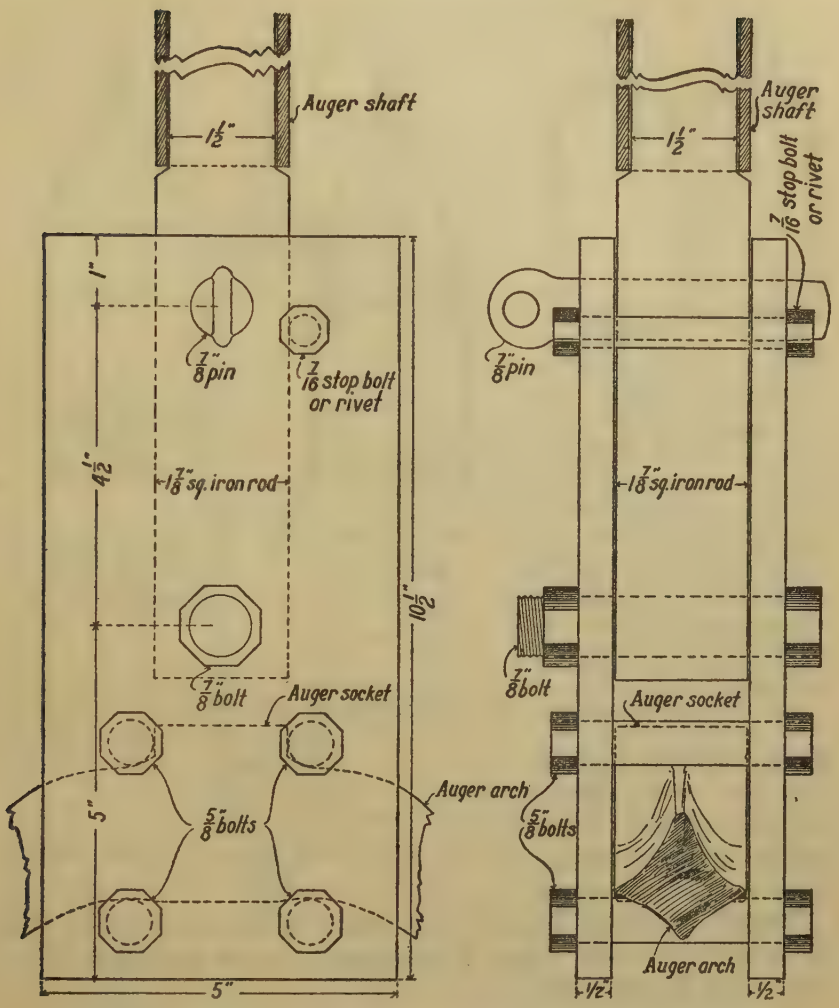


FIG. 23. A hinge for the same purpose as those shown in figs. 21 and 22.

FIG. 24. An auger designed by A. L. Savignac for the United Fruit Co. This auger works in soft mud. Note the hinge for dumping.

auger bottom can be removed from the shaft by taking out the main bolt. Another type of hinge, used on an auger designed by Mr. A. L. Savignac for the United Fruit Company, is shown in fig. 24.

An excellent auger can be made locally as shown by fig. 25. The blades of this auger can be

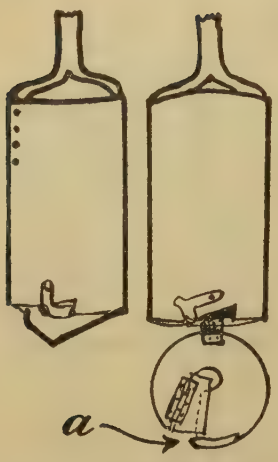


FIG. 25. A clay and sand auger that can be made locally. Augers of similar design are sold by many manufacturers without the flap valve *a*. R. R. Howell & Co., Minneapolis, manufacture these augers. A hinge on the shaft is not needed because the bottom of the auger swings back on a hinge to empty the contents.

opened quickly by hitting the catch, allowing the bottom with blades to swing on a hinge out of the way.

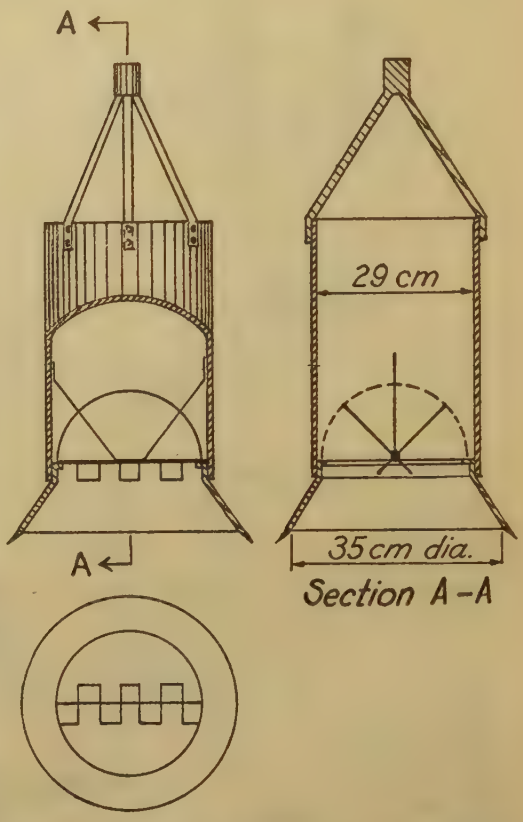


FIG. 26. A valve auger designed by Doctor Hamilton in Java.

Doctor Hamilton designed the auger shown in fig. 26. We have not given this auger a trial and are not prepared to report upon its efficiency.

The engineers of the Sarawak Oil Fields designed the auger shown in fig. 27, but this auger costs 65 dollars to make locally without shaft or other accessories. It requires six men to handle it and no doubt is useful if properly handled.

OTHER CLAY AND SAND AUGERS

There are many kinds of these augers on the market. A style frequently used a number of years ago and still used in many places is the disc auger (fig. 28). We have tried a number of these augers but find them not as satisfactory as the other augers described.

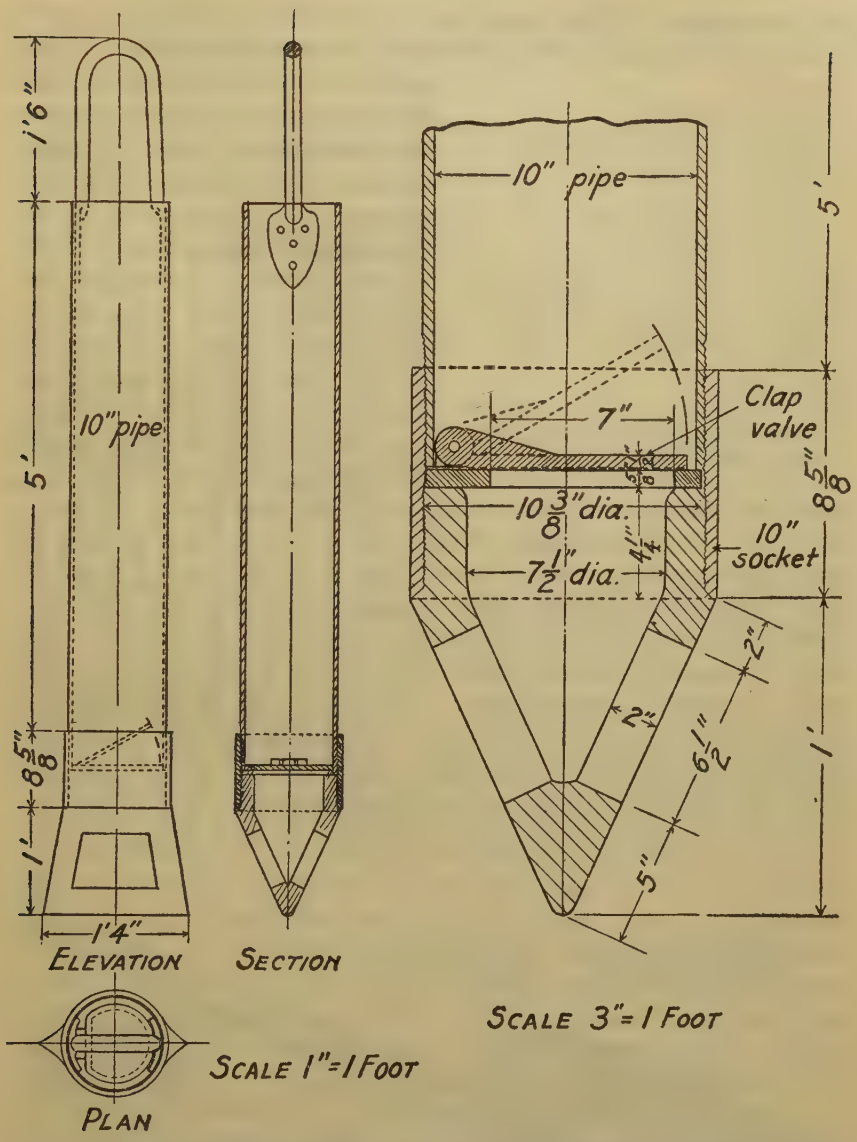


FIG. 27. A short chisel-bottom bailer designed by the engineering department, Sarawak Oil Field, Ltd., Miri, Sarawak. This drill should be a good one, but is expensive to make and requires six men to handle effectively.

The Standard earth auger (*fig. 29*).—In some places these augers, which are equipped with extension bits, have been used. They are fine augers for making holes of small diameter and have the advantage of being made so that the blades open to facili-

tate dumping. These augers give excellent service in certain kinds of work, but after a thorough trial in the Straits Settlements in making holes large enough for bored-hole latrines we decided in favor of other augers. The Iwan post-hole augers for instance cut 14- or 16-inch holes more rapidly in the variety of soils we encountered.

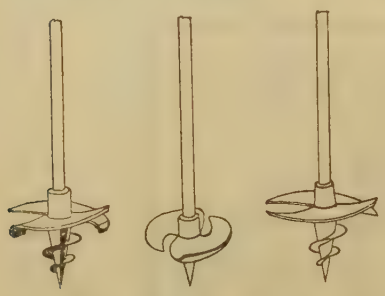


FIG. 28. Disc augers. These are probably the cheapest augers made, but are not as good as other augers mentioned.

The Lang borer (fig. 30).—This auger is used in a number of countries, but in early trials it did not meet with much success in the soil in the Straits Settlements. Holes were cut with the Iwan auger in one-third the time required in the same soil with the Lang borer. The handles and extension rods of the Lang borer are likely to bend, and there is a great waste of time using the coupled joints recommended by the manufacturer and in using the lifting bars sent with the auger. The suction created in some soils when lifting made this job difficult compared to other augers. An advantage of the Lang auger as equipped by the manufacturer is that it will work successfully in soft sand, and the Iwan post-hole auger will not work in very soft sand without modification. The Lang 14-inch auger with deep boring attachment costs 7 pounds 8 shil-

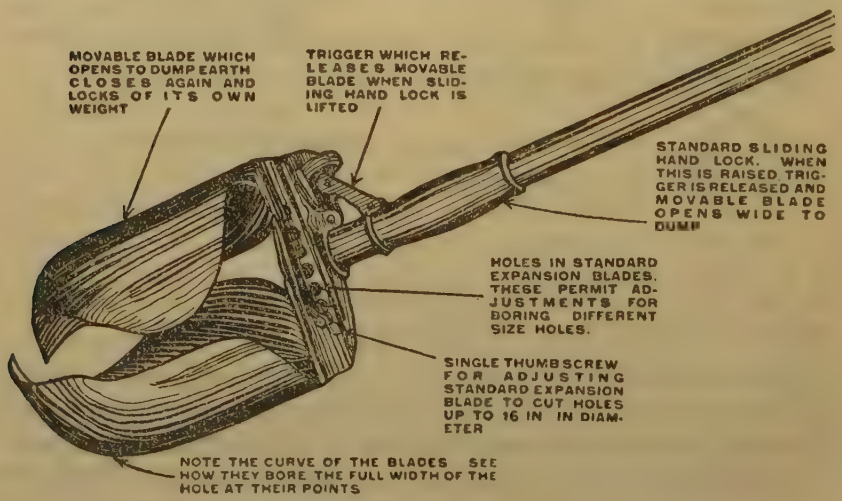

MOVABLE BLADE WHICH OPENS TO DUMP EARTH CLOSES AGAIN AND LOCKS OF ITS OWN WEIGHT
TRIGGER WHICH RELEASES MOVABLE BLADE WHEN SLIDING HAND LOCK IS LIFTED
STANDARD SLIDING HAND LOCK. WHEN THIS IS RAISED TRIGGER IS RELEASED AND MOVABLE BLADE OPENS WIDE TO DUMP
HOLES IN STANDARD EXPANSION BLADES. THESE PERMIT ADJUSTMENTS FOR BORING DIFFERENT SIZE HOLES.
SINGLE THUMBSCREW FOR ADJUSTING STANDARD EXPANSION BLADE TO CUT HOLES UP TO 16 IN IN DIAMETER
NOTE THE CURVE OF THE BLADES SEE HOW THEY BORE THE FULL WIDTH OF THE HOLE AT THEIR POINTS

FIG. 29. The Standard auger, sold by the A. J. Alsdorf Corporation.

lings 9 pence, and with five extension rods, two levers, one spiral joint, and one steel chisel, costs 19 pounds 6 shillings 3 pence. A report recently received states that the Lang auger is now made with rods and handles heavy enough to stand the strain of deep latrine boring. If the manufacturer of this auger used a larger one-piece shaft and longer turning bands the cost could be reduced as well as the time required for boring. The coupled shaft is unnecessary for latrine boring in most places. The shaft as supplied can be taken apart for shipment, but this is not a great advantage, because an auger is usually used in one area for a long time and carried from house to house completely assembled.

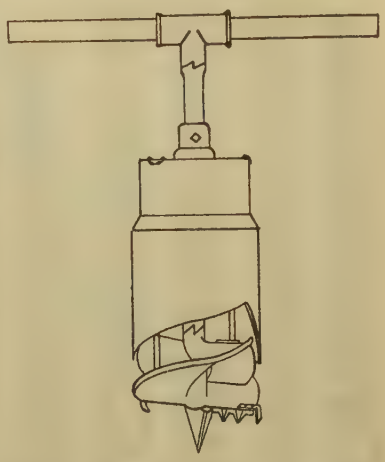


FIG. 30. The Lang-London, Ltd., auger. This auger is used in many places in clay and especially in soft sand. When used in sand a special screw, shown in fig. 18, *c*, is attached.

Howell's augers.—A variety of augers manufactured by R. R. Howell & Co., Minneapolis, Minnesota, and used by drive-well men are shown in fig. 31, *a* to *f*. These augers are too long and heavy for a squad of four men to handle. The spiral auger for loose sandy soil shown in the same illustration is carried in stock by the manufacturer in sizes up to 16 inches in diameter. The worm of this auger is 4 feet long. We have not tried this auger, but it would probably be more satisfactory for latrine work if made only half this length unless several men or a power-driven machine is used. The 12-, 14-, and 16-inch diameter augers cost 40, 45, and 50 dollars, respectively. These augers should be worked through a casing, if the sand does not pack tightly enough to keep it from running out.

The drop-bottom auger shown in fig. 31, *g*, has been used for years by well drillers. It is an excellent sand and clay auger but heavy, and the 16-inch size costs about 50 dollars.

The spudding jet auger shown in fig. 31, *h*, is for rock drilling but is slow and requires a heavy rig. It is used in well drilling but dynamite is faster and cheaper in latrine installation.

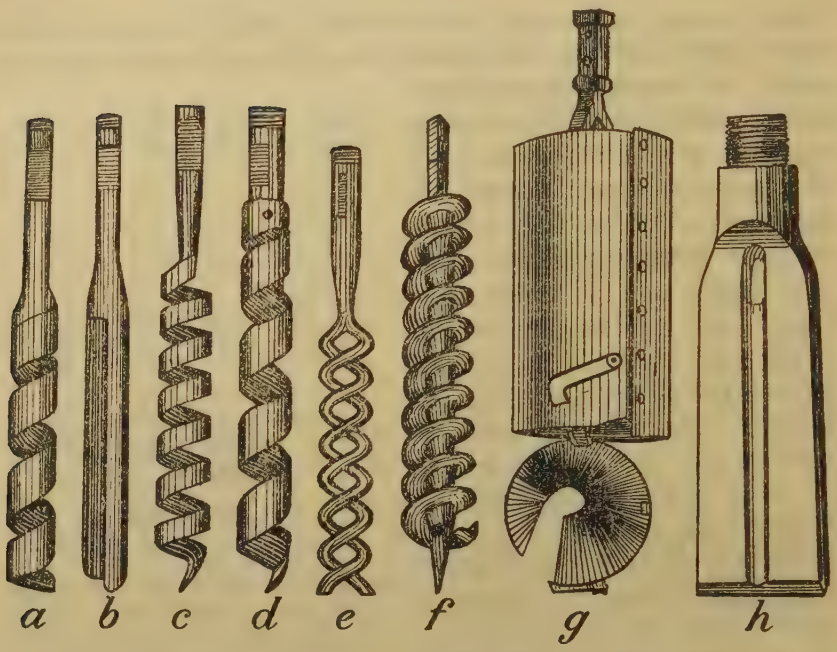


FIG. 31. Various earth augers manufactured by R. R. Howell & Co. *a*, For clay and hard pan; *b*, for boring and removing core; *c* and *d*, for general boring; *e*, for loosening and removing stones; *f*, for loose sand soil; *g*, a drop-bottom, fast-cutting auger especially useful with power-driven machines; *h*, a spudding, jetting drill used in rock drilling. Blasting is much more rapid for latrine installation in rock.

GEARED AUGERS FOR MAN POWER

Geared apparatus that can be turned by hand is made by a number of manufacturers, but the speed gained in drilling does not justify the expenditure for latrine boring and the apparatus is more difficult to transport and set up than the apparatus described in the first part of this article. The geared drills for making the 1-inch blast hole are worth the money. The geared hand augers made by Ingersoll-Rand for cutting 16-inch holes cost about 1,750 dollars United States currency.

ANIMAL-DRIVEN AUGERS

If horses, bulls, or other animals are available heavy rotary or studding drills can be used. These outfits are shown in fig. 32. In most villages where latrines are to be installed there is not enough working room to rig up apparatus of this kind, and by the time the outfit is set up a hole made by laborers would be well under way. Animal-driven boring apparatus is

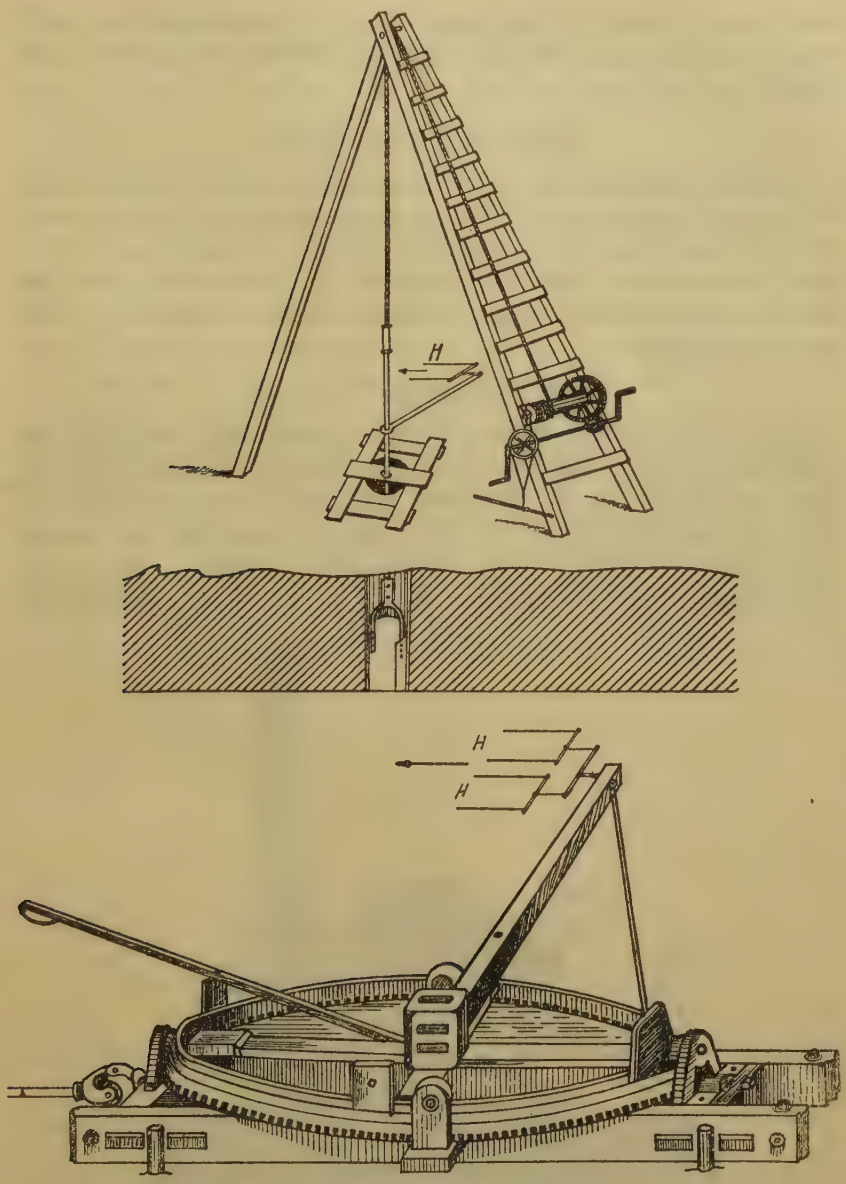


FIG. 32. Animal-driven boring apparatus. Used for many years in well drilling, but not suitable for rapid latrine boring.

valuable for deep-well drilling, but is not practical for 20-foot latrines; therefore, the heavy equipment used for this purpose will not be described in this article. Heavy augers, the bits of

which cost about 60 dollars each, have been designed for eight men or animals and do not speed up latrine boring enough to justify using them.

POWER-DRIVEN MACHINES

A power-driven auger to be of practical value must be small and easily transported. There is no doubt about the efficiency of these machines, and there are plenty of statistics to show that power-driven holes can be made for less money per hole than by man power in places where a large number of holes are to be bored.

BUDDA-HUBRON EARTH DRILL

One of the most compact, easily transported, rapid boring machines is the Budda-Hubron auger shown in fig. 33. For latrine boring this is the handiest and one of the most efficient machines on the market. It will bore in nearly all soil formations including shale, frozen ground, and hardpan. The apparatus usually sold for post holes bores to a depth of 10 feet.

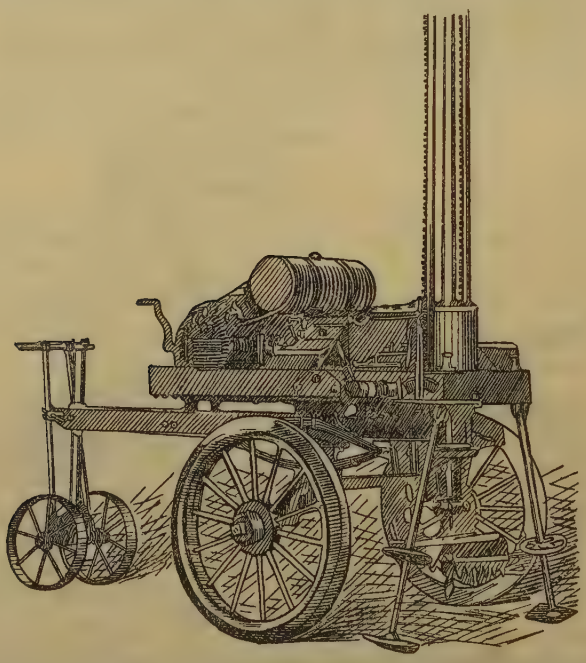


FIG. 33. The Budda Hubron machine drill. This is an efficient rotary drill, and takes less operating space than any machine we have heard of. It can be used for boring in clay, sand, hard pan, shale, and frozen ground. The stock machine bores holes 10 feet in depth, but the manufacturers will equip it for boring 20-foot holes. It costs about 2,400 dollars United States currency.

With special equipment this machine will bore a hole 20 feet deep. The machine can be equipped with small drills for making blast holes or holes up to a diameter of 24 inches. The manufacturer has certified records showing that this machine sunk fifty-four 7-foot by 22-inch holes in clay and gravel in nine hours at a cost of 0.454 dollar per hole. Hand methods cost 2.70 dollars per hole. Many other records are available.

THE GUS PECH MACHINE

The apparatus shown in fig. 34, manufactured by the Gus Pech Foundry and Manufacturing Company, requires an operation space of 10 by 16 feet, which rules it out for latrine installation in most places. The machine will bore from seventy to eighty post holes a day in some soils and will work in any kind of soil free from rocks. The machine is powerful enough to handle a 24-inch auger, and a reamer to cut 36-inch holes. There are some disadvantages in constructing these large diameter latrines, but if boring in an area where numerous large bowlders are encountered it is easier to remove these obstructions than to try to bore through them. A 16-inch drop bot-

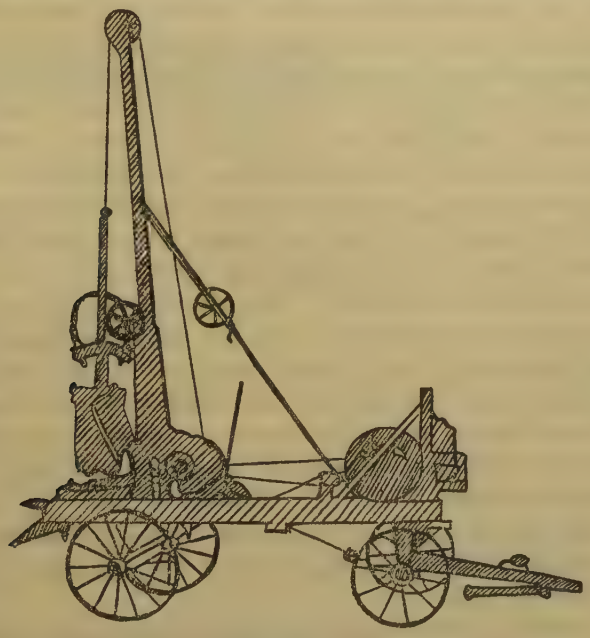


FIG. 34. The Gus Pech power-driven machine is a rapid borer, but requires a space 10 by 16 feet for efficient operation. It costs less than 1,000 dollars equipped for latrine boring.

tom, double-bit auger sells at 45 dollars. The 24-inch auger with reamer costs 60 dollars. Equipped to bore 16-inch holes 20 feet deep, a 6-horse-power gasoline engine, and a number of accessories, the machine sells for 842.50 dollars. There is an additional charge of 145 dollars for exportation boxing.

THE KEYSTONE, MONITOR, STAR, AND OTHER MACHINES

There are many machines, including those mentioned, on the market that I assume could be adapted to latrine boring, but I do not know of any better suited to the purpose than those described. All of the manufacturers making these machines deal in a large variety of augers and accessories. A disadvantage of all these machines is the large space required for operation. The Budda-Hubron requires less space than any power-driven machine that has come to my attention.

BORED-HOLE LATRINES IN ROCK

Expensive power equipment will cut through rock without difficulty, but to suit Philippine conditions it was necessary to develop an inexpensive method of latrine installation, because there are many towns near Manila and in other parts of the Islands built on strata of tuff. In an article submitted to the Rockefeller Foundation the formation, correctly named tuff, was referred to as adobe rock, as locally termed. Tuff in the Philippines is found in several degrees of hardness.

The softest tuff can be cut with a pick, but the hardest grades break into sharp-edged irregular pieces when blasted with dynamite, but is not as hard as granite or the solid rock formations met with in some places. The so-called adobe rock in the Philippines does not melt away in the rain as adobe does in many countries. This tuff stands weathering for centuries as seen in some of the old unprotected walls and churches. The harder formations of tuff offer more resistance to boring than the laterite frequently encountered in Malaya or the hardpan that is found in other countries. Tuff is a deposit of lava and volcanic ash that by pressure and other causes has hardened and forms extensive strata varying from a few inches to 30 feet or more in thickness.

Many towns are built on outcrops of this rock, where the pail system and other methods of disposal of dejecta were too expensive; therefore, such places had no latrines.

The problem of making holes economically in these areas seemed impracticable until the method of making tunnels for railways and water-ways led to the idea of making miniature tunnels vertically instead of horizontally. The method is the same in both instances. Dynamite does the work faster and cheaper than any auger made. In our first attempt we blew the surface of the earth to pieces several yards around the mouth of the hole, as shown in Plate 7, fig. 1, but with a little modification in the method, cylindrical holes with clean-cut mouths and straight sides can be made to any depth desired. We have installed hundreds of these latrines within a few feet of the houses. Some of these holes have been blasted within 2 feet of the walls of the houses and others have been put down under the floors. Any person who understands the use of dynamite can install these latrines in crowded communities without any danger to the inhabitants or houses.

The method of blasting varies according to the kind of rock encountered. Some of the tools employed are shown in fig. 35. Fig. 35, *a3* and *a4*, shows two views of a drill for making blast holes in hard rock. This drill is not needed in adobe formations.

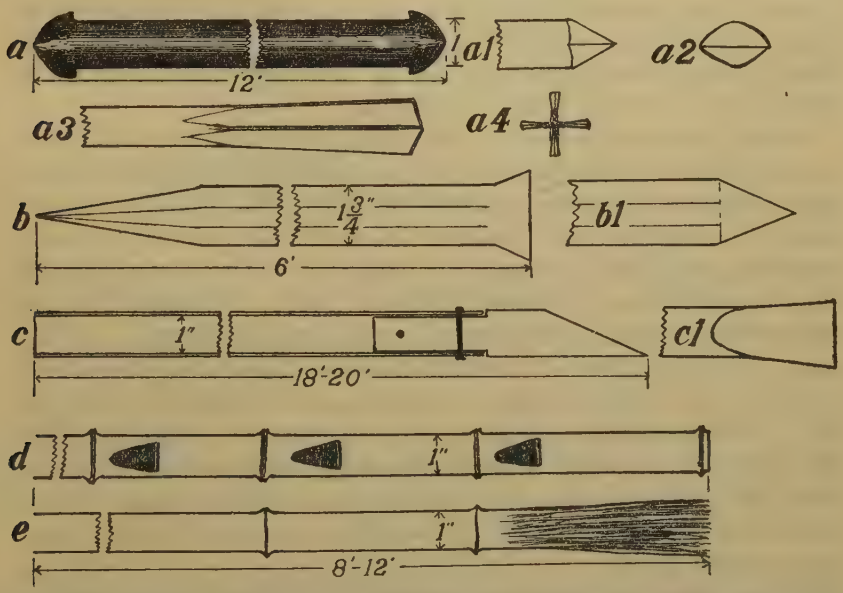


FIG. 35. Tools used for blasting latrines in rock. *a*, Bar used in drilling blast holes in tuff, adobe rock, and other hard formations; *a 3*, drill used with hammer for making blast holes in hard rock; *b*, crow bar used for starting latrine or straightening side; *c*, long bar used occasionally in deep latrines; *d*, bamboo bucket for removing water from blast holes; *e*, bamboo brush for cleaning mud out of blast holes.

Making holes in tuff.—If the stratum of the tuff lies 2 feet or more below the surface of the earth, the ordinary post-hole auger or shovels are used to cut the hole through the sandy clay earth down to the level of the hard layer. When this layer is reached, three to five small holes (fig. 36) about 1 inch in diameter and 2½ feet deep are drilled with the steel bar shown in fig. 35, *a*. Each of these holes can be drilled in ten to fifteen minutes by using the bar with a ramming and twisting motion after pouring a little water into the hole. A hammer is not used except in very hard rock. The water and mud that accumulate in the holes are removed with the bamboo bucket shown in fig. 35, *d*, and the holes are cleaned out with the bamboo brush, *e*. The bucket, *d*, can easily be fashioned from bamboo with a pocket knife, and the brush is made by pounding the end of a bamboo pole. The position of the holes, the direction of drilling, and the charge of dynamite to be used in each, depend upon the work to be done. One blast hole in the center of a large 16-inch hole with a large charge of dynamite is not satisfactory if the large hole is shallow, because the blast will destroy the surface. Better results are obtained in making 16-inch cylindrical holes if three to five small holes are drilled in the position indicated in fig. 36, *a*. A charge of one stick of ¾-inch 40 per cent dynamite in each small hole is sufficient. The fuses are all ignited as rapidly as possible. The explosions follow each other in rapid succession.

When the latrine is 4 to 6 feet deep, the dynamite will break up the adobe or pulverize it to an additional depth of 3 to 5 feet below the bottom of the blast holes. If the adobe pulverizes an auger is used to remove it, but if it breaks into pieces a bucket and rope is used. A man can be let down into the hole to gather up the larger pieces of rock. We make latrines at least 16 inches in diameter if men must go down. At this stage after the adobe is removed it will be found that the latrine is from 9 to 11 feet deep. Another series of small holes (fig. 36, *c*,) with another charge will be enough to make a latrine pit about 18 feet deep. We frequently drill three or four blast holes at the first level, four at the second level *b*, and five for the last detonation at level *c*, placing one or two sticks of dynamite in each hole.

If the adobe is an outcrop and not covered with soft earth, a hole about 16 inches in diameter and 18 to 24 inches deep should be cut into it with a chisel-shaped bar (fig. 35, *b*). If the rock is very hard the work may be expedited by a few light charges

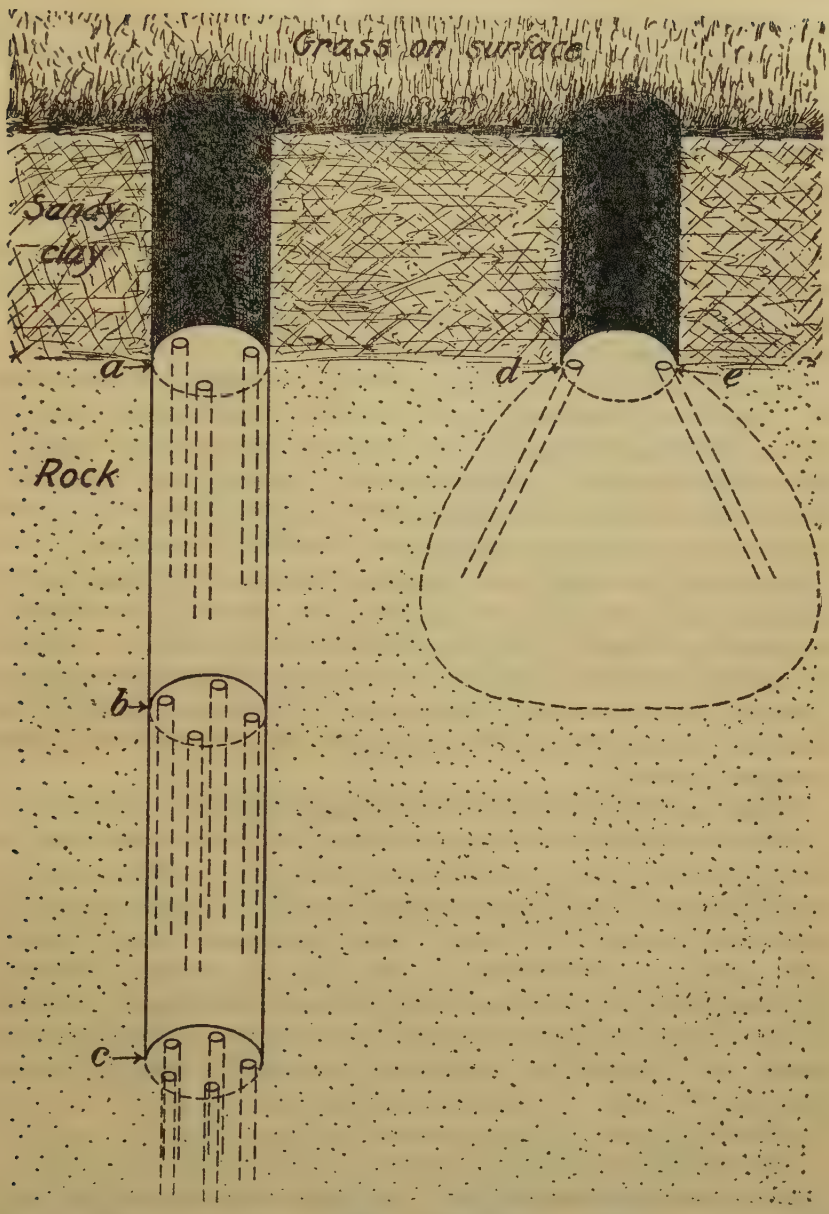


FIG. 36. Blasting in rock. *a* to *e*, Positions of blast holes. In hard rock five blast holes are drilled at *a* and *b*.

of dynamite; but this is not often necessary even in the hardest tuff. When the large hole is 1½ to 2 feet deep, the work of charging the small holes with one stick of dynamite each can proceed without damage to the surface. Sometimes the dyna-

mite will blast out a wide hole beneath the mouth of the small hole, and leave a shelf in the latrine. This shelf can usually be broken through with the long chisel (fig. 35, *c*) or, if necessary, a small charge of dynamite may be used.

Dynamite does not blow long fissures in comparatively soft tuff, but usually pulverizes it so that it can easily be removed with an auger. Occasionally, broken pieces several inches long and of irregular shape are blasted loose. The dynamite can be set off with the usual fuse and cap, but if much work is to be done it would probably be better, in the long run, to use an electric machine for this purpose.

In most places we have made straight cylindrical holes 18 to 20 feet deep. In other places we have first made holes 15 inches in diameter and 6 or 8 feet deep, and then, by drilling two small holes at an angle (fig. 36, *d* and *e*), have made the large hole 3 or 4 feet in diameter down to a depth of about 10 feet. At one school we constructed a series of five holes 3 feet from center to center, and then blew out the partitions at the bottom, thus connecting the holes by an opening large enough to permit a man to walk from one hole to the other. In other places we have connected and installed pipes in the partitions so that the holes acted as a septic tank. There was sufficient absorption in the holes in soft adobe that a pipe to carry off effluent was not needed.

Holes in the hardest tuff will give better service if the area around the bottom is split into fissures to allow greater absorption. This is done by drilling one blast hole in the center at the bottom of the latrine and setting off a charge of several sticks of dynamite. This will blast numerous fissures several feet long in all directions. If the rock is not then sufficiently absorbent, two latrines should be made so that the dejecta can be allowed to age in one hole while the other latrine is being used. It is easier to pump out a full latrine than to bore a new one in rock. A machine and hand-driven pump are used in the Philippines for pumping out latrines.

We have used from two to twelve sticks of dynamite in making holes in various kinds of tuff. In a large school latrine an average of seven sticks per hole was used. With the tools mentioned, two men can install a latrine in tuff in a day or less. Dynamite costs 24 pesos, or 12 dollars United States currency, for a case of two hundred sticks, delivered in Manila. In hard tuff the dynamite for one latrine costs from 42 to 72 cents. The

cost of installation, while higher than boring in soft earth, is cheaper in most places than any other method of latrine construction in hard formations. Dynamite and labor cost about 4.50 pesos per hole if only twelve men are hired to lower the overhead cost per hole. The foreman's wages of 3 pesos per day are included in the cost.

The cost can be considerably lowered by spending a little more money for tools. We had a special blast-hole drill made by the Howells Mining Drill Company that speeds up the work. It not only bores the blast hole but automatically cleans the hole while boring. This auger, shown in fig. 37, costs 18 dollars delivered, including an extra twist drill. The drill will cut adobe rock, shale, laterite, hardpan, and other hard formations. It will not cut the hardest grades of tuff. A more-rapid automatic feed, geared drill that costs 140 dollars is shown in fig. 38. Air and electric drills are much faster and will cut hard rock but are expensive unless there is a great deal of work to be done.

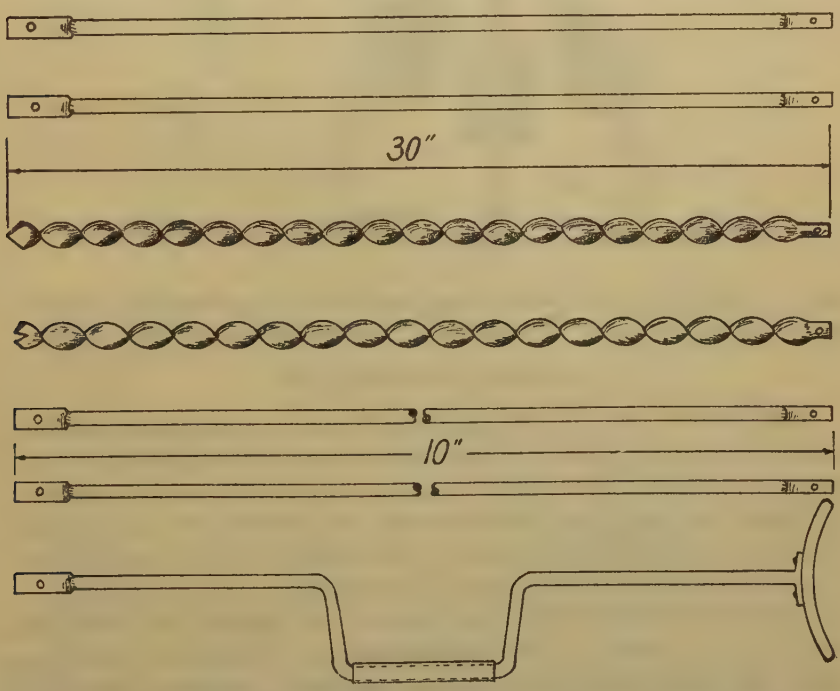


FIG. 37. A hand drill especially designed for making blast holes in tuff, adobe rock, shale, or other hard formations. It will not cut hard rock. This drill cuts the holes rapidly and cleans them out at the same time; it is constantly used now in place of the bar *a*, fig. 35 except in the hardest rock where the drill *a*3 is used. Manufactured by the Howells Mining Drill Co., Plymouth, Pa. Cost about 18 dollars.

Dynamite exerts a more powerful explosive force in hard formations than in soft material, and the hardest rock cannot resist a charge of dynamite. While this method has not been used for our latrine installation in the hardest kinds of rock, it is believed that the method will work in any rock formation, and in any formation is much more rapid than the spudding rock drill shown in fig. 31, *h*, or any other drill designed for hard formations.

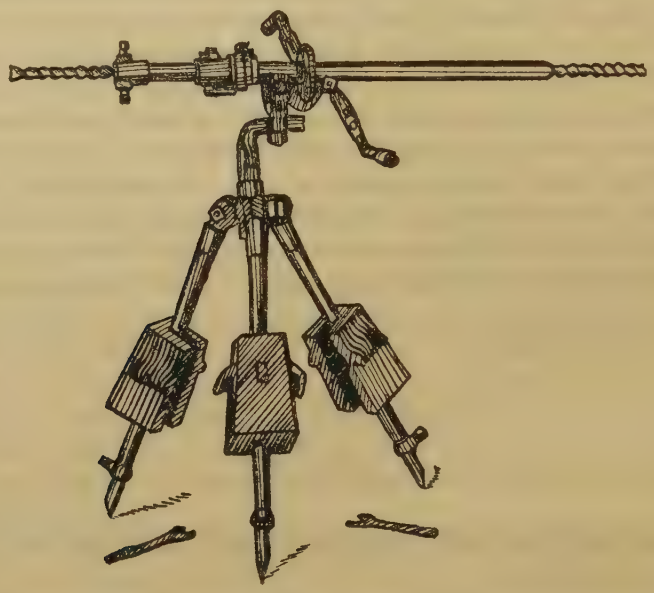


FIG. 38. A geared drill for boring blast holes rapidly in very hard formation except hard rock. Manufactured by Howells Mining Drill Co., Plymouth, Pa. Cost, 140 dollars.

LATRINE CONSTRUCTION

The method used in making holes in rock might have been included in section under Construction but a description of the tools used should be included under equipment, so the method of using the tools was included with the description of the tools in order to describe completely the method of latrine installation in rock without referring to other parts of the article.

Boring latrines in ordinary soils.—The method of using the hand auger needs no detailed description. The auger is turned until full and then pulled up and emptied. After a few trials the number of turns necessary to fill the auger can be determined. The number of turns varies in different soils. The Iwan post-hole auger takes about 6 inches of soil every time it

is filled. This observation is useful when boring under water where the auger cannot be seen. A mark on the shaft can be noted and when it reaches a level of 6 inches below the starting position it indicates that the auger is full and ready to be hoisted and emptied. Soft soil can at times be kept from falling

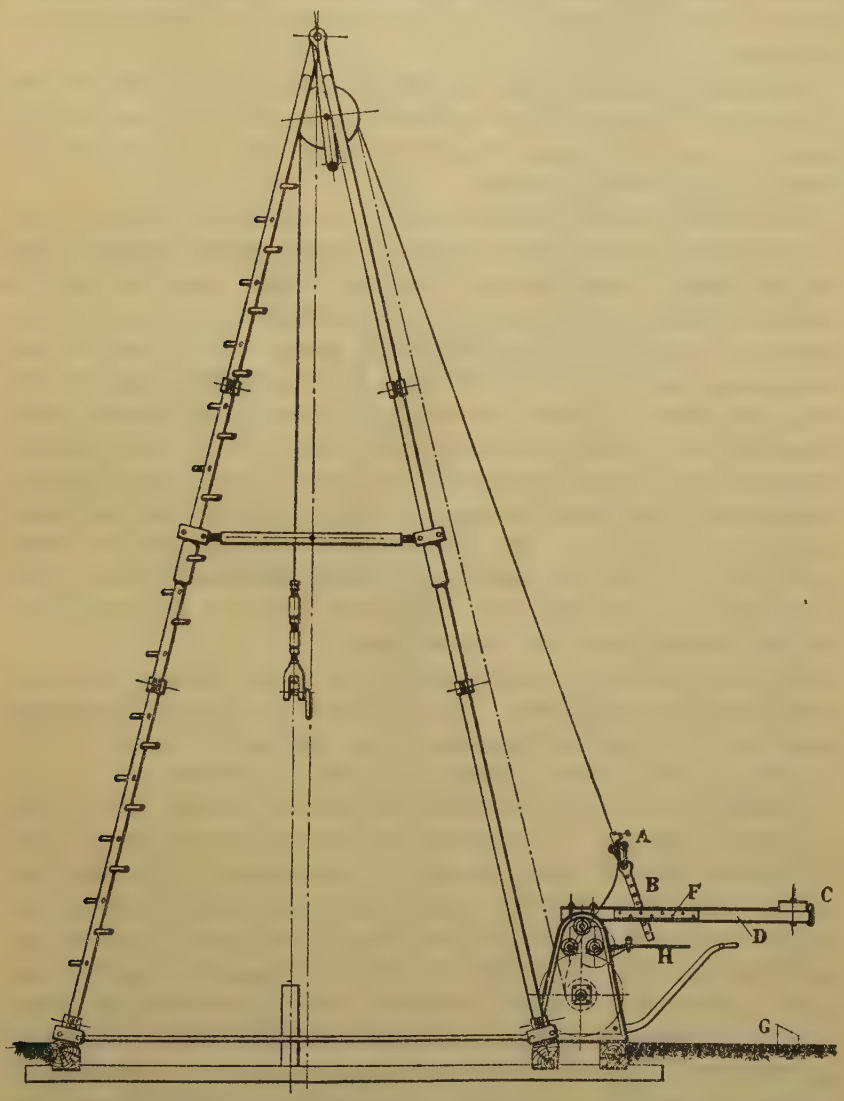


FIG. 39. Derrick manufactured by Werf Conrad, Haarlem, Holland. For rotary, percussion, or free-ball system of boring. This apparatus will handle heavy drills. It is too heavy for general bored-latrine work.

out of the auger by a smooth steady pull instead of a jerky motion when lifting. Some soils will not fall out of the auger until after it is pulled out of the water. At times it is best to continue a steady pull all the way up, and in other instances it is advisable to stop lifting as soon as the auger is pulled above the surface of the water to let the excess water drain out about a half minute, allowing the soil to pack itself and then continue hoisting.

Soils of average consistency pack so tightly in the auger that they must be removed with a small scoop or sharpened paddle made of metal or wood. Boring is easier in very dry soils if water is poured into the hole.

Bored latrines can be installed in places where water is not encountered, but the disintegration of the dejecta appears to be not as rapid or complete as in latrines with a meter or two of water in them. The dry latrines evidently do not last as long as those containing water, but with proper use a latrine not containing water should not be filled by an average family in less than four years. We had a complaint in which two latrines were reported filled within seven months, but investigation showed that nearly one hundred persons were using these two latrines. Ample provision should always be made to install a reasonable number of latrines for the convenience of the persons who will use them. There are records of other latrines lasting three years and not yet half full. In these instances from eight to twenty persons used the latrines daily.

A squad of four men can easily bore an average of three latrines a day in sandy clay. This includes setting up the apparatus and time lost in transportation, and covers work by the month, and not a spurt of energy for only a few days.

Caving soil.—Lining or reënforcement to prevent caving are important features of construction. There is one area in the Philippine Islands where the people went ahead with bored-hole latrine installation without preliminary consideration of the soil encountered, and no trial latrines were bored before general installation started. Evidently in this area the soil was of a consistency that the walls of the latrines did not cave in when bored, but when the heavy rains came most of the latrines filled up with caved-in soil. This was damaging to our propaganda because a number of persons were convinced that bored-hole latrines are not suitable for the Philippine Islands.

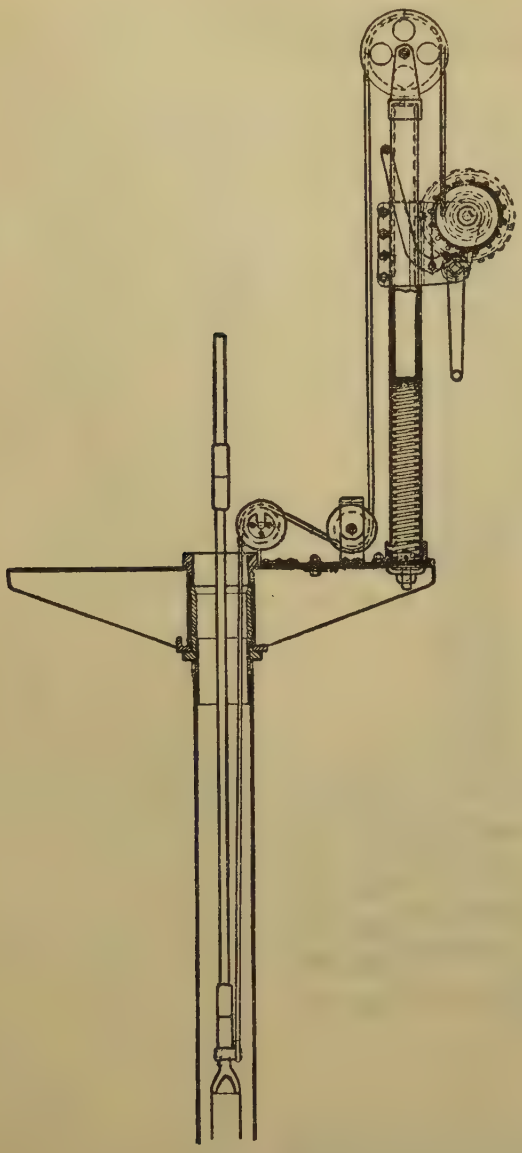


FIG. 40. Hand-power spudding and hoisting windlass manufactured by Werf Conrad, Haarlem, Holland. Believed to be too expensive (about 200 dollars) and too bulky for general distribution for latrine boring.

In many places the earth caves in only at the mouth of the latrine. In these areas wooden cement kegs which can usually be obtained at no expense are used. One cement keg pushed into

the mouth of the latrine and allowed to extend about 6 inches above the mouth is a commonly used method. Clay is packed around the protruding keg, the slab is placed on top, and then the superstructure is built.

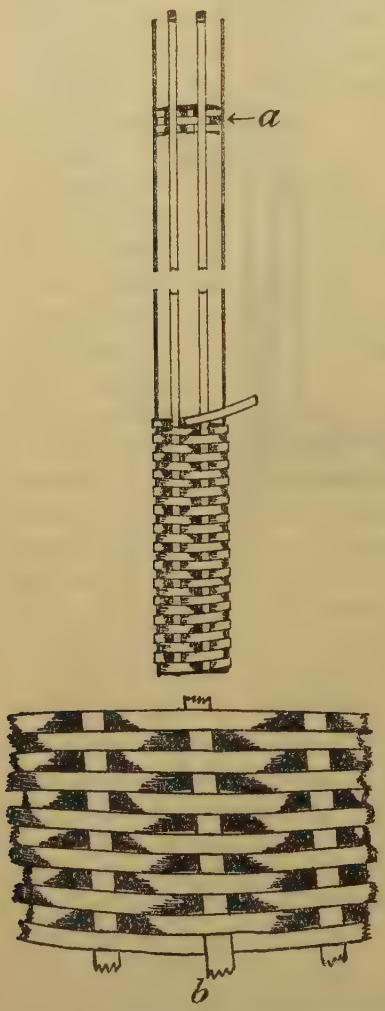


FIG. 41. Woven-bamboo cylinder partly made. This makes a very satisfactory latrine lining in most places. The section *a* is a temporary support to keep the ribs straight while weaving; *b* is an enlarged section of the woven-bamboo latrine lining.

To prevent caving in areas where the walls are likely to cave in the entire depth of the latrine, plaited bamboo or wickerwork linings, or cylinders made of cement, clay, wire, wood, or sheet metal are used. Drums or kegs placed end on end have been frequently used in the Philippines. The bamboo linings are very satisfactory especially if coated with coal tar or some other wood preservative. In some places the latrines are bored to a depth of 12 or 14 feet below the water level. Bamboo under water lasts years without a preservative; therefore, in these areas it is not necessary to use a preservative on the portion of the lining that will remain under water. The wood extending above the water level is more likely to rot or be eaten by insects. In many tropical countries the bamboo will last as long as the latrine and is cheaper to replace if necessary than to use preservatives. A woven bamboo lining is shown in fig. 41, *a*, and an enlarged sketch showing the weaving is shown in fig. 41, *b*. These woven linings were first used in Java and have been used satisfactorily in the Straits Settlements, and are extensively used in the Philippine Islands and other countries. The bamboo cylinder can also be made by tying long

bamboo strips to hoops. In some places where they do not have bamboo they fasten strips of another kind of wood to metal or wooden hoops.

Dr. Victor G. Heiser suggested the use of an open mesh galvanized wire screen as this would allow the bacteria naturally in the soil to act on the dejecta and also allow permeation of the latrine contents into the soil. We have recently tried wire screen made into cylinders as shown in fig. 42, *a*. The only disadvantage is that chemical action might cause rapid disintegration of the metal. In some places the bamboo cylinders would probably last longer, but wire can be obtained in places where there is no bamboo. A thin wire netting ordinarily called chicken wire net can be reënforced with wood or iron hoops, but is too flimsy for practical use. A mesh of $\frac{1}{4}$-, $\frac{1}{2}$- or 1-inch heavy wire does not require the hoops and withstands corrosion longer. These cylinders cost about 3 pesos for each section 3 feet long. Sheet-metal cylinders can be made as described in the next paragraph, but numerous holes should be chopped into the metal to allow better action on the dejecta.

Silting-earth reënforcement.—In order to prevent caving in silting earth a solid lining is required. Bamboo cylinders are very satisfactory in some places, but we have frequently found

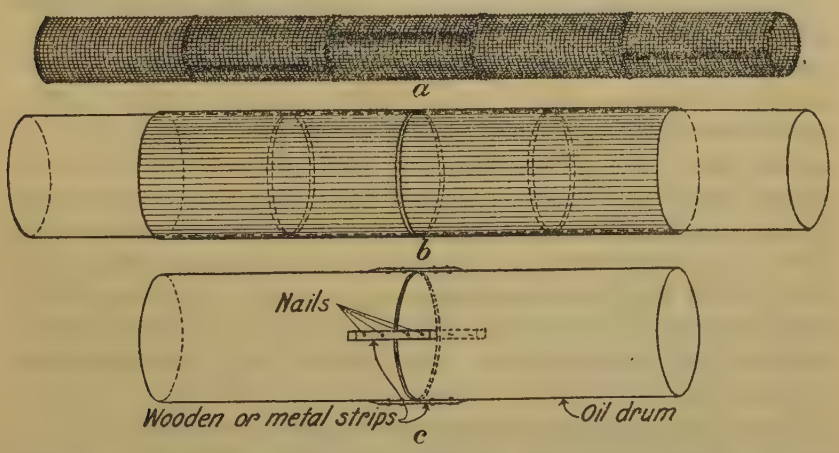


FIG. 42. Various latrine linings. *a*, A galvanized-iron wire-net lining which can be used in places where white ants eat the bamboo or where bamboo is not available; *b*, stovepipe double wall, "wall method" of making a lining. In ordinary soils numerous holes can be cut into the metal to allow better action. In silting soils the sections are added one at a time as boring proceeds. A few dents hold the cylinders together; *c*, four to six empty metal oil or tar drums placed end on end are frequently used as linings for latrines. The heads of the drums are cut out with a chisel. Wooden or metal strips are nailed to the drums to make strong joints. These are often used in silting sand.

it necessary to cover the cylinder with a thin coat of clay or weak mixture of cement in order to prevent very soft sand from silting through the small openings in the cylinders.

In most places in the Philippines we use cylinders that we can get for little or nothing. Heavy sheet-iron oil drums with the ends cut out and tar and cement drums have been very satisfactory. We frequently use wooden cement kegs placed end on end.

When using sheet-metal linings in soft sand we rivet the cylinders with five or six small rivets. We make the cylinders 3 feet long for convenience in handling. A few slits can be chopped into the lower cylinders to allow a rise and fall of water if necessary. Each cylinder is slit in four places at one end to allow it to be inserted an inch into the next cylinder.

Stove-pipe method of lining.—When only very thin sheet metal is available we use the stove-pipe-well method. A number of cylinders are made in two diameters each 3 feet long so that the smaller cylinders can be telescoped or slid into the larger cylinders. These make an excellent reënforcement and are convenient for boring in very soft sand. The joints overlap in the center and a few dents with a hammer prevent slipping. Fig. 42, *b*, shows the position of the joints.

If the soil is stiff enough to hold its shape long enough to bore to the required depth, the lining is put down in one or two long pieces. If the soil constantly caves in from the sides while boring, the cylinders, which are a couple of inches larger in diameter than the auger, are put down the latrine one section at a time, and the sand is pulled up through the cylinder by the auger. The cylinders are pushed down every few minutes in order to block off the silting soil as rapidly as the auger cuts. If thin metal cylinders are used, a hoop of iron should be fastened around the bottom cylinder to maintain a circular opening. If this is not done the sides will be compressed by the mud or sand and the auger will not turn or will hook under the edge of the cylinder.

Iron oil drums with the ends cut out and placed end on end are used in the same way as the sheet-metal cylinders, and have been very useful in reducing the cost of latrines in soft silting sand and mud near Manila. A satisfactory way to joint the cylinders together is shown in fig. 42, *c*. Three or four strips of wood hold the joint solidly. Nails are driven through the wooden strips and drum and clinched on the inside. Nails are

difficult to drive into heavy oil drums unless holes are previously punched through.

Slabs or floors.—Under exceptional circumstances we have allowed the use of wooden slabs or floors in latrines but for obvious reasons usually insist upon the use of cement slabs. A variety of slabs have been designed in many countries with as many different sizes and shapes of holes. In some places plain reënforced concrete slabs are made with rectangular holes in the center. In other places they use elevated treads or so-called foot plates for the feet to prevent fouling. A slab that has been used successfully in Java is shown in Plate 7, fig. 2. Plate 1 is one of the types recommended by the Government of Madras, India. They also use a circular slab. The Java slab costs less and is the smallest slab we have heard of. In other places they use slabs over 4 feet long. In the Philippines we most frequently use the reënforced slab shown in Plate 2. This slab is 30 inches wide and 36 inches long. It is $2\frac{1}{2}$ inches thick at the outside with a sloping surface for drainage reducing the thickness to 2 inches at the edges of the holes. The edges of the holes are cut back to prevent fouling. Knowing of two instances in which children fell through holes 8 by 18 inches in one country, the rectangular hole in the slab used in the Philippines is made only $5\frac{3}{4}$ inches wide and 13 inches long. In casting the slabs a notch 3 inches on each side is made at each corner for the posts of the superstructure. This allows the walls to be built close up to the edge of the slab.

Another kind of slab is also used in the Philippines; it is of the same general dimensions but with the hole narrowed at the front and with two elevated treads or foot plates for the feet. This slab costs a little more to make than the plain slab, which costs from 1.85 to 2.45 pesos including $\frac{1}{4}$-inch twisted wire reenforcement, a 1, 2, 3 mixture of concrete, and the labor. The plain slabs are more easily handled in shipping than those with treads, and up to the present time have not been found fouled any more frequently than the slabs with foot plates.

Dr. W. P. Jacocks designed an excellent latrine floor or "squatting plate" for Ceylon. This plate is made of 18-gauge pressed steel and can be purchased for 4 rupees or less from Messrs. Walker, Sons & Co., Ltd., Colombo (fig. 43).

The floors of latrines should always be at least 18 inches above the highest water level. If the water level is several feet below the surface of the earth and the rainy or flood season does not

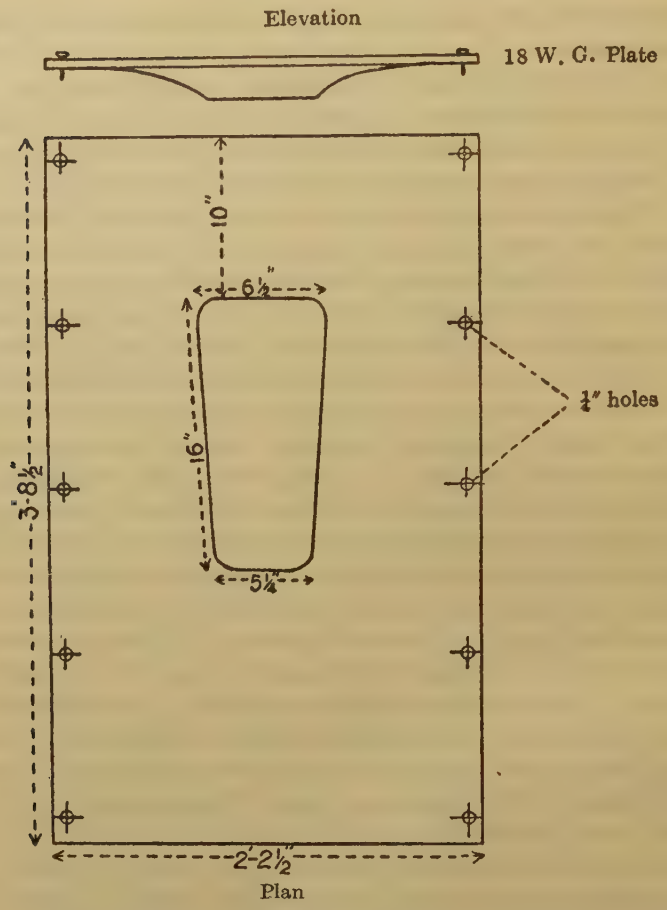


FIG. 43. A steel latrine floor, or squatting plate, designed by Dr. W. P. Jacocks for use in Ceylon. The cost is about 4 rupees, about 2.60 pesos.

raise the water to the surface the slab can be placed directly over the hole on a level with the surrounding soil.

In places where the water floods over the area the floor and the superstructure can be built upon mounds of clay. In these places the lining can be allowed to extend above the surface of the earth to the required level and clay, bricks, stones, cement, or other material can be placed around the protruding lining to support the slab. We sometimes use blocks of tuff or adobe cemented with clay or lime, but in most instances on account of the possibility of spreading infection from the latrine we use cement to make the structure solid and without crevices.

At times we run the cement a foot or more below the surface down around the lining or dig a small trench about a foot away

from the bored hole and fill this with cement. While there is probably no seepage under a heavy slab with its support, the above precaution tends more completely to block any exit of infection. In places where the people do not have enough money to build a solid structure, we frequently use discarded oil drums with the ends cut out for the support of the slab. The drum extends about a foot into the mouth of the latrine and 2 feet above the surface where the water floods the area to about a foot in depth.

The water trap.—There are many houses equipped with flush water closets emptying into bored latrines. In some of these two or three bored holes are connected together with pipes and are better than many septic tanks. Where they do not have piped-in water but have the money to purchase a porcelain water closet, the bowl is placed on the slab directly over the bored hole and after using is flushed with a bucket of water.

One of the advantages of the bored-hole latrine installed in suitable places where the subsoil water is encountered at a depth of about 16 feet, is that mosquitoes, flies, and other objectionable insects do not breed in the latrines and no bad odors are emitted. One objection to the bored latrine in places where the ground water lies within a few feet of the surface of the earth is that it furnishes a breeding place for flies and mosquitoes and is offensive unless properly constructed. The ordinary slab is not satisfactory in these places and the cost of vitreous china bowls is too great for a large proportion of the rural inhabitants. To meet the demand reënforced concrete water traps have been made. The design first used was copied from a porcelain water closet. A small bucket of water is sufficient to flush the bowl completely. One feature of the trap is a clean-out hole, which facilitates cleaning when necessary. These traps have been greatly improved by making them longer and putting foot treads on them. We have now two types of traps so designed that the dejecta must fall where supposed to at the back of the water closet. It is impossible to squat on these water closets backwards because the treads slope to the front and throw a person off balance when he tries to squat on the trap the wrong way.

One of these water closets is designed to be placed on top of a concrete slab, and the other is designed so that it fits flush with the slab, except the treads, so that the floor drains into the trap. The traps are made of cement and cost about 4 pesos each for

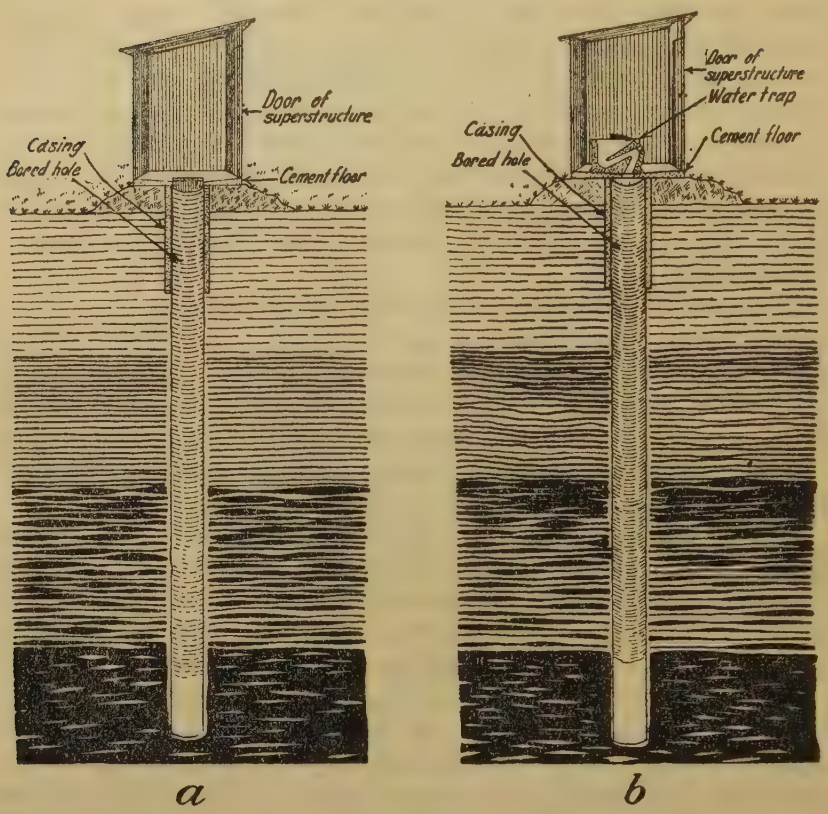


FIG. 44. Latrine and water closet. *a*, The bored-hole latrine complete with superstructure. The lining and cement casing are not used in soil that does not cave into the latrine. Metal drums are usually used instead of cement casings where the water rises to the surface; *b*, a cement water closet that can be flushed with a bucket of water. About two hundred of these water traps are giving excellent service in the Philippines. The sloping foot rests make the user sit on the water closet correctly. The rests throw one off balance if he attempts to squat backwards. These traps cost about 4 pesos each. They absolutely eliminate fly and mosquito breeding and foul odors.

material and labor. A few baked-clay traps have been made, but these are not as satisfactory as the cement water closets (Plate 4 and figs. 44 to 46).

We recommend these flush water closets for private families only and not for use in public latrines, because careless people block them with rubbish. Nearly two hundred water traps have been in use over a year and are a very satisfactory improvement to latrines where the water level is high.

These traps have been placed over latrines that were covered with swarming maggots and emitted very objectionable odors.

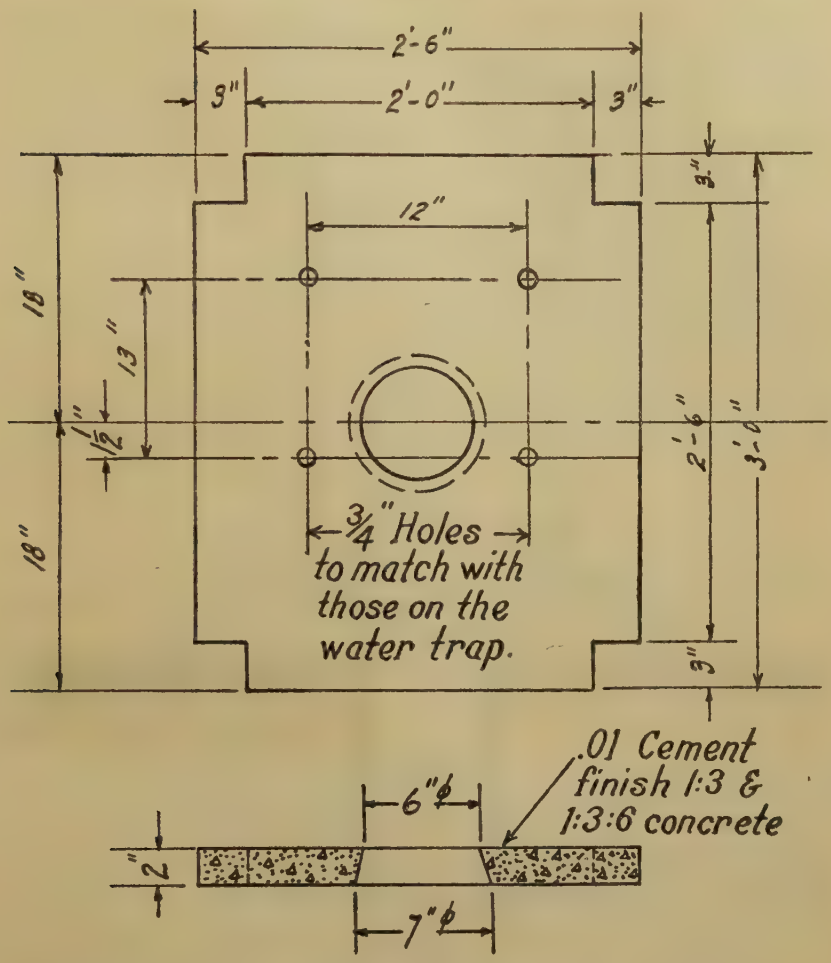


FIG. 45. Reënforced concrete slab for use with water trap. Elevated type.

After installation of the traps and cleaning the latrines there was no longer any fly or mosquito breeding and the odor disappeared immediately. Another advantage of the trap is that the people learn almost immediately to use water or paper instead of sticks and other articles, and the latrines will serve a greater length of time.

Superstructures.—In this section on latrine construction there is no attempt to discuss the building of superstructures. There are so many kinds of superstructures that are satisfactory and the details are of such little importance, as far as the prevention of disease is concerned, except in one point, that it is unneces-

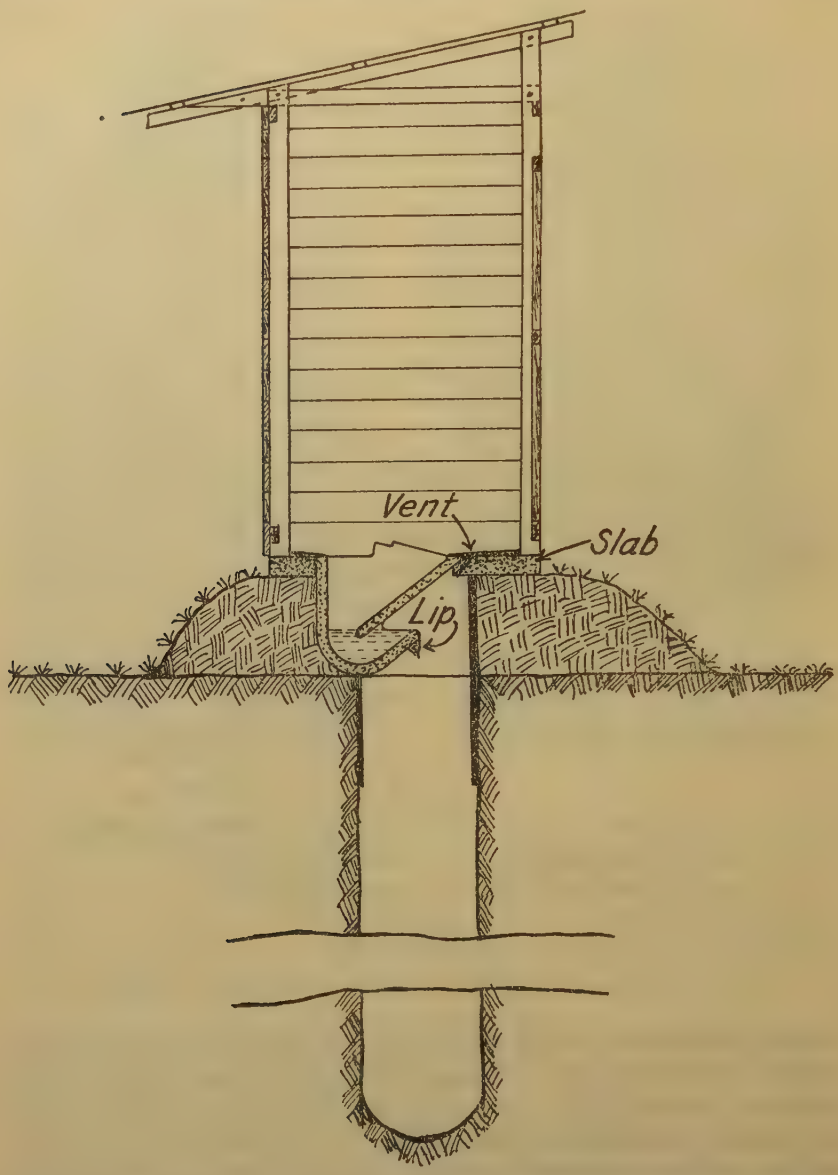


FIG. 46. Latrine equipped with water trap sunk flush with the slab. This trap costs only 3 pesos. Note the sloping foot rests and the small vent, which can be opened to relieve pressure in an air-tight latrine. The washings from the trap fall from the lip and do not follow the trap down to the wall of the latrine.

sary to take the space required to include a description in this article. Sometimes the latrines are bored so that the seat or slab can be placed in the house or in a position easily accessible

by an elevated board walk leading from the house to the latrine. There are many places in our rural areas where they do not build a complete superstructure, but only palm leave partitions on three sides of the latrine with a screen of palm leaves erected a couple of feet in front of the entrance for privacy. There is only one detail in the building of superstructures in which we are particular and in which the builders of the superstructures are more or less careless. In some places they build the superstructure so large that a space of a foot or more of earth is left uncovered by flooring between the slab and the walls of the superstructure. In these instances there is danger of soil pollution around the sides of the slab where the earth is shady and moist and this furnishes an excellent culture medium for parasitic larvæ and other disease organisms. We insist upon the walls of the building being placed against the slab so that the floor of the latrine is all concrete.

A complete bored latrine of the usual type is shown in fig. 44, *a*. The bamboo lining and a cement or iron casing shown in this picture are not needed in solid ground which does not cave in.

The laborers' privy as built with a seat by the United Fruit Company is shown in Plate 5. This sketch also shows their method of lining latrines.

Dr. Louis Schapiro forwarded a pamphlet to us from Siam showing an ingenuous latrine that is fool proof as far as keeping the hole in the floor covered. In order to use this latrine the lid must be pushed back. When the lid is in the open position the door cannot be opened because it strikes a handle on the lid. Therefore, in order to leave the latrine the lid must be closed so that the door can be opened (Plate 6).

BACTERIAL MIGRATION

Regardless of the results of the experimental work attempting to determine the limits of bacterial migration, it is advisable to frequently examine well water for pollution in every community. Some of the work done in the past throws some light on the possibilities of pollution. There is considerable evidence showing that bacteria do not travel more than a few feet in dry soil and in some instances not even one foot from the latrine, but more information is needed to show the distance bacteria will travel in ground water. Bacteria have been carried several thousand feet in ground water flowing through fissures in lime stone and other formations.

W. A. Hardenbergh discusses the results of a considerable amount of work on pollution in his book on home sewage disposal. The United States Public Health Service, through an experimental board directed by Dr. Charles Wardell Stiles, reports bacterial migration 200 or 300 feet, and states that possibly greater distances are covered under most favorable conditions.

Stiles, in "The principles underlying the movement of Bacillus coli in ground water, with resulting pollution of wells," states that *B. coli* were found in ground water 65 feet from a polluted trench. These bacteria evidently traveled through a fine sand with an effective size of 0.13 millimeter. It took 187 days for *B. coli* to travel this distance, and the migration was only in the direction of the flow of the ground water. In another article, "Experimental distribution of Bacillus coli in the soil under and near pits," by C. W. Stiles and C. L. Pfau, it is stated that *B. coli* were carried in ground water up to at least 232 feet.

Space cannot be given in this article to discuss the viability of organisms, but the resistance of the pathogenic bacteria which are likely to infect man through drinking water is not great. Most of these bacteria die within a few days. Typhoid bacilli might live months in polluted soil on the surface, but the bactericidal action at ground-water levels is greater. Kligler states, typhoid and dysentery bacilli may be recovered up to seventy days in moist natural soil. The rapidity of time in transmission is an important factor in well pollution.

Although Stiles found no convincing evidence of the travel of *B. coli* against the flow of the ground water, there is no reason why these bacteria and other organisms could not migrate against the flow in some places. In areas where the water does not flow constantly in one direction or at times is almost at a standstill, the motility of the organisms as well as migration by growth would be factors in the spread. Cholera and choleralike vibrios can actually travel against the flow of a current. Schöbl has demonstrated this point many times. Hardenbergh states that "pollution appears to travel against the flow of ground water as well as with it." Other workers have made similar observations. However, the migration of bacteria against the flow is relatively unimportant.

A factor in migration that is sometimes not considered is the kind of soil in which small channels form. In some soils there is practically an even filtration. In other soils of the same effective size of sand there is a cohesive quality which affects filtration. An even filtration might be expected, but examination reveals

that the water is flowing into the well in small rapid-flowing streams through a few long channels some of which are branched. In these places the bacteria are not subjected to the same filtering action as in a soil where there is even filtration.

Although Israel J. Kligler [2] states that the "pollution of wells is usually surface in origin," the direct pollution through ground water is pointed out in his summary, as follows:

The problem has been approached both from the experimental and practical standpoint. In the laboratory repeated tests have been made to determine: (1) the viability of the typhoid and dysentery bacilli in soil and in excrement under different conditions; (2) their ability to penetrate through columns of soil of different porosity; (3) their viability in septic fluids and effluents; and (4) the nature of the antagonistic factors in soil and septic material which influence the viability of these microörganisms. In the field work various types of privies of different ages were examined particularly with regard to (1) the extent of pollution of the soil surrounding these privies; (2) their relation to well pollution; and (3) the passage of material from the privies through the soil to adjoining wells.

The main conclusion arrived at on the basis of both the experimental and field observations is *that in moderately compact clay, sand-clay, or sandy soil, free from cracks, the possibility of subsoil pollution of the ground-water is negligible, provided the ground-water level is more than ten feet below the polluted area.*

The following facts were established:

1. The typhoid and dysentery bacilli succumb rapidly on exposure to an unnatural environment. (*a*) Both typhoid and dysentery bacilli die out in 1 to 5 days in septic tanks. (*b*) In solid feces the typhoid bacilli may survive for a period of 10 to 15 days, while the dysentery bacilli rarely survive longer than 5 days. The paratyphoid bacilli are the most resistant members of the group; the Shiga dysentery bacillus is the most sensitive. (*c*) The survival period of these organisms in soil is greater than in either feces or septic fluids, and varies particularly with the moisture and reaction of the soil. Temperature effects the viability, but the two main factors normally are moisture and reaction. In moist natural soil of a pH value of 6.6–7.4, the typhoid and dysentery bacilli may be recovered up to 70 days. In the same soil dry, the bacilli are not recovered after 2 weeks. In moist acid soils, pH 4.8–5.4, 90 per cent of the inoculated bacilli die out within the first 10 days, the others may survive as long as 30 days. All the organisms survive longer near freezing temperature (4° C.) than at higher ones (20–37° C.). (*d*) The antagonistic action of soil bacteria on typhoid and dysentery bacilli is due largely to the alkaline reaction resulting from their metabolism. Specific inhibitive substances are, however, elaborated by some soil bacteria, notably *Bacillus fluorescens* and *Bacillus proteus.*

[2] Rockefeller Institute Monograph 15.

2. The spread of pollution from a focal point is limited in scope. (*a*) Typhoid and dysentery bacilli under experimental conditions were not observed to spread laterally to any appreciable extent, although they were carried vertically through a column of 2 feet of porous soil. In denser soil they failed to penetrate through 1 foot. (*b*) In the field, where the subsoil was free from pollution, either near pit privies or near tile pipes from septic tanks, contamination extended downward to a depth of 5 to 8 feet, and laterally only about 3 feet, from the bottom of the pit or tiles. (*c*) Heavy rains or constant dripping of water may carry surface pollution to a depth of 10 feet.

3. Pollution of wells is usually surface in origin. (*a*) There was no correlation between the type or proximity of the privy to the degree of contamination of the adjacent wells. The purity of the well water varied rather with the condition of the well. Driven shallow wells with pumps were, as a rule, free from contamination, while dug wells with pumps or buckets were generally grossly polluted. (*b*) Experiments with fluorescine failed to show subsoil pollution of wells from privies, but proved in some instances at least the possibility of surface contamination.

According to Kligler, F. A. A. F. Eykin and G. Grijns, working in the Tropics, made similar observations. They found very little pollution in the soil around pits not reaching the groundwater level and in only one case traced pollution 5 meters from the pit. *Bacillus coli* was not found at a depth of 20 inches from the bottom of the pit, but during wet weather the penetration was about three times as great. As stated by W. A. Herdenbergh—

> In the case of high ground water, these authorities seem to think that much pollution is from the soil directly into the ground water and thence to the well, with the privy having no part in the process. This would appear to fall under the head of surface pollution and illustrates how mechanical (or animal) transportation of pollution may be an important factor in the spread of disease.

The Commission on Additional Water Supply for New York City found that polluted water was rendered safe to use after flowing through 25 feet of fine sand. In abstracting a report of this observation W. A. Hardenbergh states:

> The report of the Commission on Additional Water Supply for New York City, made by Burr, Hering and Freeman, records some experiments on the same subject. The tests were made at Elmont, L. I. While it is stated that the passage of polluted water at low velocities through twenty-five feet of the finer sands, such as are found in Long Island, will render the water safe to use, it is also shown that, under severe conditions sewage bacteria and B. coli may pass through soil for a considerable distance. In most cases, a lesser distance than twenty-five feet may be considered safe, it is stated.

Shallow pits if unprotected from surface water, according to the investigations of the Public Health Service at Wilmington, North Carolina, and other observations, are a source of danger. In the work at North Carolina, pits filled with surface or rain water carried pollution to the ground water below, and from pits reaching the ground water *B. coli* traveled a distance of 200 feet.

Most investigators agree that if the ground water is not polluted the chance of infecting wells through the soil is very remote, and that most water supplies are infected from surface pollution. Quoting Hardenbergh:

> Dr. C. T. Nesbitt, at that time Health Officer of New Hanover County, N. C., made a series of tests in 1917 at some mill villages near Wilmington. He found pollution of the ground water from effluents from septic closets, in some cases up to twenty feet from the effluent pipe, beyond which distance he made no tests. The results in this case were generally such as to indicate that the sand-clay soil of that region does not fully protect the ground water from fecal pollution, nor prevent the travel with underground water of such pollution for uncertain distances.
>
> This indication was borne out by the bacteriological examination of about 700 shallow driven wells located in the city and county. The only wells of this kind free from pollution were those located 200 to 500 yards away from any concentrated source of pollution, as stables or privies. The bacterial counts in those wells not so located were extremely high, and the presumptive tests for B. coli were almost unfailingly positive.

I do not have a reprint of the work on these 700 shallow wells, and do not know if there was surface pollution or not, but in many other places a careful examination has revealed surface pollution of most of the wells.

In Manila there are 42 artesian wells from 345 to 900 feet in depth, which are not likely to be contaminated from ground water. Pollution was found in many of these wells, but careful examination showed the possibility of surface pollution. After the concrete platforms around these wells were elevated and the well heads repaired presumptive *B. coli* were seldom found and the bacterial counts were reduced to satisfactory limits. Shallow wells would not have shown such good results. In fact satisfactory water drawn from a depth of 20 feet has never been found in Manila. We have no evidence showing that bored-hole latrines reaching the ground-water level have ever infected a properly constructed deep well. In many villages the cost of numerous shallow wells, which are sources of danger regardless of bored-hole latrines, is greater than the cost of a deep well;

therefore deep wells are recommended where satisfactory piped-in water cannot be obtained.

Rosenau * shows a picture of the "popular idea of how wells become infected from surface pollution," and states, "this rarely takes place in rural districts, as the soil can usually hold back most of the impurities." Similar pictures are shown in many elementary books on hygiene, public-health pamphlets, and posters. It is more reasonable to show direct pollution from the surface where bacteria obviously have easy access to the well.

According to Rosenau, "The viability of typhoid bacilli in feces is very variable, depending on the composition of the feces and the varieties of other bacteria present." Sometimes typhoid bacilli in fæces perish in a few hours, and under other conditions have been found to live five to seven months. The life of the organism in privies and in water is usually comparatively short. "In nature they seldom, if ever, live in water beyond 7 days, and are often dead in 48 hours." They probably live longer in clean water than in contaminated water, but soil polluted on the surface is most dangerous. The deleterious effect of antibiosis, chemicals, temperature, light, dissociation, sunlight, filtration through soil, and other factors affect bacteria.

Rosenau refers to the use of dyes and chemicals to determine the sources of pollution. He regards these tests as valuable in indicating the possibility of danger under certain circumstances and finds them useful in discovering the sources of pollution near wells or in limestone formations. He points out the possibility of error in concluding that microörganisms and dangerous pollution travel an equal distance to the chemicals, stating "the soil has well-known filtering power when free from fissures or open channels and is capable of removing bacteria and oxidizing large quantities of organic matter."

On the other hand Rosenau records the travel of *Bacillus prodigiosus* to a distance of 200 meters in forty-two hours. He does not describe the soil nor state whether or not there was surface travel. The cultures were poured into the ground.

Rosenau cites many examinations under, "interpretation of sanitary water analyses," in some of which there was evidently pollution from soil surcharged with organic matter, and another instance in which there was remote pollution in which organic matter was mineralized and the bacteria held back by the soil,

* Preventive Medicine and Hygiene, page 951.

and a number of wells in which there was direct infection from the surface.

It is believed by many that the *B. coli* and count tests do not give the information required. Some pathogenic bacteria will die where *B. coli* might survive in an acid soil. The cholera vibrio lives best under alkaline conditions. Dr. Otto Schöbl, of the Bureau of Science, Manila, suggested the use of a cholera-like vibrio which is easier to identify than *B. coli* and responds to enrichment in peptone broth. This organism is a much better indicator for cholera than *B. coli,* and work is now under way in the Philippines on the migration problem. Doctors Ramirez and Basaca, of the Bureau of Science, have given much of their time to the bacteriological technic.

In an article, entitled "Well pollution and safe sites for bored-hole latrines," an attempt was made to caution health officers as to the possible danger of installing latrines near shallow wells. This piece of work was not intended as a scientific check on previous bacteriological work on migration that has been published by a number of bacteriologists. The work had to be done in a very limited length of time, and the number of examinations were limited. Latrines were being installed within a few feet of shallow wells, and the experiment showed that bacteria in that area would travel in subsoil water considerably farther than this distance. As stated in the article, "The entire experiment was of such short duration that we make no pretence of presenting a complete piece of work. However, the results give a fair indication of the degree of possible contamination of water-supply situated within short distances of bored-hole latrines in a similar soil." This was only a preliminary piece of work, and it served its purpose until more complete work could be undertaken.

Credit should be given in this article to all persons who have contributed toward the development of the bored-hole latrine, but the names of individuals other than those mentioned are not available.

The three following paragraphs are quoted from a report submitted by Dr. John L. Hydrick to the Rockefeller Foundation:

> After the rural hygiene campaigns in Java had been in operation for a few months, the sanitary inspectors noticed that in the areas in which the simple pit latrines were deep enough to reach groundwater the floors of the pits were covered with black sludge and a thick scum floated on the water.

Since the odors of fermentation from these latrines were not more objectionable than those from dry pits, Dr. van Breemen, city health officer of Batavia, decided to carry out some experiments with a type of latrine devised several years ago by one of the field officers of the Dienst der Volksgezondheid in Nederlandsch Indie.

This field officer had noticed that the small borers used on the estates for digging holes for fence posts and telephone poles were easily handled by the laborers and that with very little difficulty holes could be dug to the groundwater level. He suggested that these borers be used to make simple pit latrines, since fecal material deposited in a deep pit which reaches groundwater would undergo fermentation. The action would be similar to that of a septic tank; a narrow deep hole should be usable over a long period of time, and, on account of its small diameter, its walls would be less liable to cave in after heavy rains.

There are published articles on latrine boring that have not yet been received. This publication covers methods developed locally, descriptions furnished by manufacturers, and reports forwarded by Dr. Van Wesep and Mr. Rollin C. Dean, of the Rockefeller Foundation. Dr. Victor G. Heiser has contributed much information and many valuable suggestions at frequent intervals. Many officers in the Straits Settlements and in the Philippine Health Service, especially Dr. Jacobo Fajardo, director of health, and Dr. Gabriel Intengan have given active coöperation in the work. Mr. Cecilio Marcelino has given much of his time in making molds for water traps. We are indebted to Mr. Eugenio Viana, superintendent of San Lazaro Hospital, for his active coöperation in the construction of many preliminary designs of cement slabs, water traps, and other work.

Mr. Mañosa, chief of the Sanitary Engineering Department of the Philippines, and Messrs. Diaz, Claustro, and Bagabaldo have given valuable service in latrine installation.

I am indebted to Dr. William H. Brown, director of the Bureau of Science, Philippine Islands, for editorial suggestions and corrections. Mr. R. C. McGregor, associate editor of the Journal of Science, has rendered valuable aid in editorial corrections of this article; and Macario Ligaya and Francisco Rafael, of the Bureau of Science, have spent a great deal of time redrawing many of the pictures.

ADDRESSES OF MANUFACTURERS AND DEALERS AND WHAT THEY SELL

There are many manufacturers and distributors of boring equipment, but the following list will be sufficient to allow a selection of inexpensive equipment as well as modern up-to-date machinery.

The National Supply Corporation, 120 Broadway, New York City, and 185 Queen Victoria Street, London, E. C. 4., have in stock or can obtain almost anything in boring equipment known.

The Oil Well Engineering Co., Ltd., Cheadle Heath, Stockport, England, and R. Richards & Co., Upper Ground Street, London, S. E., deal in an extensive line of boring apparatus.

Werf Conrad, Drilling Outfits Department, Haarlem, Holland, manufacture the Banka hand drill, which is not practical for bored-hole latrine work, but they have derricks, a variety of augers, chain tongs, and many useful accessories.

The Ingersoll-Rand Company, 11 Broadway, New York, manufacture an enormous variety of power-driven machinery that will drill anything. They sell the "calyx" hand-power geared outfit that can be equipped with a clay auger to bore 16-inch holes. This apparatus sells for about 1,750 dollars. They also sell drills for making blast holes in rock.

The Keystone Drill Company, Beaver Falls, Pennsylvania, with offices at 170 Broadway, New York, manufacture a large variety of power drills, and numerous types of clay augers, sand pumps, bailers, rock drills, and other equipment.

The Star Drilling Machine Company, Akron, Ohio, manufacture portable well-drilling machinery, confined to the churn or percussion-type drill, which is not practical for latrine boring. They manufacture many types of auger bits and accessories.

The Okell-Well Machinery Corporation, 2035 Bay Street, Los Angeles, California, quote a price of 1,798.91 dollars for a complete boring machine including a seven-horse-power motor and a full line of accessories.

R. R. Howell & Co., Minneapolis, Minnesota, are manufacturers and jobbers of a full line of drilling machinery, augers, and supplies.

Sweeney and Gray Co., Inc., 81 Sixth Street, Long Island City, New York, manufacture boring equipment, and sell a clay auger with a hinged bottom for about 100 dollars. The shafting costs 40 dollars.

The Specialty Device Co., 106 West Third Street, Cincinnati, Ohio, manufacture the "Standard" earth auger discussed in this paper, a quadruple expansion brace for holding the shaft, and other useful accessories. These products are sold through the A. J. Alsdorf Corporation, 330 South Franklin Street, Chicago. The No. 10 auger equipped with extension blades costs 6.60 dollars. The brace costs 4 dollars. A 25-foot coupled shaft costs 3.75 dollars. Couplings and bolts cost 2 dollars.

Lang-London-Ltd., 34 Gray's Inn Road, Holborn, London, W. C. L., sells the Lang earth borer discussed in this paper.

Iwan Brothers, South Bend, Indiana, manufacture the Iwan post-hole auger, disk auger, and sand-digging tools. These augers can be purchased from the National Supply Co., 185 Queen Victoria Street, London, and from Lindeteves-Stokvis, Amsterdam, Holland; Batavia, Java; and Penang, Straits Settlements.

The Budda Company, Harvey, Illinois, with an export office at 30 Church Street, New York, manufacture the Budda-Hubron machine. The trailer-type machine for boring holes 20 feet deep costs 2,275 dollars and the truck-mounted type costs 2,125 dollars. This is the most compact power-driven machine on the market.

The Gus Pech Foundry and Mfg. Co., 200 Second Avenue, S. W., Le Mars, Iowa, manufacture a practical machine-driven auger, the No. 2 Monitor mounted boring machine, and a variety of auger bits, stone hooks, and other accessories that are valuable in latrine construction.

The Howells Mining Drill Co., Plymouth, Pennsylvania, manufacture the twist drill illustrated in this article, which has been especially adapted to our work for drilling blast holes in adobe, shale, and other hard formations. They also make the hand geared machine known as Howells prospector's drill, which should be equipped with bits to bore 1-inch by 2½ foot blast holes at variable depths up to 18 feet, and the weighted tripod regularly furnished or the stand used on their Spry Little Giant slate drill. They also make air and electric drills.

Oilwell Supply Co., London, and 215 Water Street, Pittsburg, Pennsylvania, sell all kinds of boring apparatus.

Armstrong Mfg. Co., Waterloo, Iowa, sell a large variety of drills.

McKiernan-Terry Drill Co., 115 Broadway, New York, sell many kinds of drilling apparatus.

EQUIPMENT AND WHERE TO OBTAIN IT

	Dollars United States currency.
Iwan post-hole auger bottom, 14-inch (dozen)	67.20
Iwan post-hole auger bottom, 16-inch (dozen)	81.60
Iwan post-hole auger bottom, 16-inch, extra heavy blades (each)	12.50
Iwan Bros., South Bend, Indiana.	
National Supply Corporation, England.	
Lindeteves-Stokvis, Amsterdam, Holland; Batavia, Java; and Penang, Straits Settlements.	
Chain tongs, 2½-inch Vulcan bijaw (each)	3.50
J. H. Williams and Co., Brooklyn, New York. National Supply Corporation, New York and England.	
Nearly all local hardware stores.	
Pulleys (each)	1.00
Local stores.	
Wilson pipe wrench (each)	15.00
National Supply Corporation.	
Drop-bottom double-bit augers for earth, sand and gravel, 16-inch (each)	45.00
Gus Pech Manufacturing Company.	
National Supply Corporation.	
Okell-Well Machine Corporation.	
R. R. Howell and Co.	
Sweeny and Gray Company.	
Clay auger, 15¾-inch, No. 1, with 20-foot boring rods (each)	95.00
R. Richards and Co., London.	
Clay auger, 14- and 16-inch drop bottom.	
R. R. Howell and Co.	
Gus Pech Manufacturing Company.	

	Dollars United States currency.
Lang earth borer, 14-inch, complete with sand-boring attachment and accessories (each) Lang-London, Ltd., England.	96.00
"Standard" auger No. 10, 10-inch, with cutters complete with 20 feet of shaft (each) A. J. Alsdorf Corporation.	10.35
The Gus Pech or No. 2 Monitor boring machine (each) Gas Pech Manufacturing Company. National Supply Corporation. Okell-Well Machine Corporation.	842.50
The Budda-Hubron machine (each) The Budda Company, Harvey, Illinois.	2,275.00
Hand-twisted drills, geared drills, electric- and air-driven drills for making blast holes in shale, slate, adobe rock, laterite, and other hard formations. Howells Mining Drill Works, Plymouth, Pa.	
Machine-driven rock drills for making blast holes in hard rock. Ingersoll-Rand Company.	

Drill steel for making bars is sold by local dealers and by Ingersoll Rand who carry in stock a large supply of standard sizes and shapes such as hexagon, round, square, pentagon, cruciform solid, and twisted concave. They also have finished sets of drill steel.

SUMMARY

The Iwan post-hole auger with locally made shaft and turning handles, an inverted V hoisting frame equipped with a compound pulley and a shaft supporting brace or hinged-door platform is recommended as the cheapest fast-cutting equipment for boring latrines in all soils except hard formations, silting sand, and soft mud.

Various shafts, turning handles, braces, hoisting equipment, and miscellaneous accessories are discussed.

Useful augers for general boring including very soft soil are the locally made augers, the auger used by the United Fruit Co., and a large number of augers on the market.

Useful augers for boring in very soft soil and silting sand are the locally made augers with hinged blades, the augers used by the United Fruit Co., the Iwan augers equipped with locally made valves, the Lang augers, and a variety of bailers, pumps, and other augers regularly supplied by dealers.

A number of hinged shafts to facilitate dumping are shown. The method of preventing caving of the latrine walls while boring in mud and quicksand is described.

A rapid practical method of installing latrines in tuff, or so-called adobe rock, and other very hard formations is described.

The method described has been used successfully since October, 1929.

Power-driven drilling machines are recommended for rapid economical boring where large numbers of latrines are to be installed and there is sufficient space for the operation of the machines.

Linings to prevent caving of the walls of bored latrines and the methods of using linings in silting formations are described.

Water traps made locally of baked clay or cement, which greatly improve the bored-hole latrine, especially where the ground-water level is near the surface, have been used successfully. These traps are described and illustrated.

A variety of cement slabs and a metal latrine floor are recommended.

The details of building superstructures are not given, but the importance of constructing the slabs and walls so that no uncovered earth is exposed to contamination is emphasized.

A brief description of bacterial migration is useful in locating safe sites for bored-hole latrines.

Dr. Victor G. Heiser suggests emphasis on proper supervision so that bored latrines are not installed in places where there is danger of infecting domestic water supplies.

A list of manufacturers and dealers with their addresses and the materials they sell that are useful for making bored-hole latrines is included.

A list of bored-hole latrine boring equipment, where to obtain it, and the prices are given.

BIBLIOGRAPHY

ROSENAU, M. J. Preventive Medicine and Hygiene (1927).

HARDENBERGH, WM. A. Home Sewage Disposal (1924).

WETERDALE, J. S. Memorandum on Latrines. Government of Madras, India (1928).

SAVIGNAC, A. L. A new drill used by the Preston Engineering Department. Unifruitco. The United Fruit Company, Boston, Massachusetts No. 9, 5 (1930) 535.

JACOCKS, W. P. A note on a type of latrine suitable for use in Ceylon villages. Ceylon Journ. Sci. § D., Medical Science, Part 2, 2 (1929).

YEAGER, C. H. The bored-hole latrine. Malay. Med. Journ. No. 1, 5 (1929) 1–3.

YEAGER, C. H. Practical bored-hole latrine construction. Malay. Med. Journ. No. 2, 4 (1929) 45–55.

YEAGER, C. H. Well pollution and safe sites for bored-hole latrines. Malay. Med. Journ. No. 4, 4 (1929) 118–125.

Reports of the Rockefeller Foundation.

U. S. Public Health Service Reports.

ILLUSTRATIONS

PLATE 1

Reënforced concrete squatting slab designed by J. S. Westerdale for Madras.

PLATE 2

One of the rectangular cement slabs widely used in the Philippine Islands. The lid and handle shown in A–A is the type formerly used in Java. The slab is reënforced with ¼-inch twisted iron. The cost is less than 2.50 pesos.

PLATE 3

Detailed sketch of the elevated water trap.

PLATE 4

Detailed sketch of the water trap and slab shown in fig. 46.

PLATE 5

Latrine used by the United Fruit Company.

PLATE 6

A latrine used in Siam fitted with a sliding lid which must be closed in order to open the door to get out.

PLATE 7

FIG. 1. The rock was shattered covering a radius of ten feet from the blast holes in our first attempt to install latrines in tuff. Clean-cut cylindrical latrines are now being blasted daily since the method was improved.

2. Small cement slab used in Java. Photograph sent by Doctor Hydrick who reports favorably on these slabs. They cost less than a gilder.

TEXT FIGURES

FIG. 1. The Iwan auger. *a*, Shaft attached to auger arch; *b*, a more solid joint with a nut below the socket. The bolts and nuts are not necessary if the shaft is welded to the arch.

2. The chain-tong turning handle, made by attaching the handle *a* to a Vulcan bijaw chain tong. This is an excellent turning device and has been used in many places.

FIG. 3. Crumbie tongs, one of the most satisfactory inexpensive tongs on the market. *a*, Old type; *b*, improved Crumbie tongs; these cost a little more, but are worth it.

4. Turning handle designed by Doctor Hamilton. "The two steel retention plates with the grooves on their inner surfaces serve to prevent the dogs from falling out of place when no pipe is between them. The plates are bolted together and to the frame of the body so that the dogs are easily removable and exchanged when worn or damaged." (Drawing from a sketch sent by Doctor Hamilton to the Rockefeller Foundation.)

5. Turning handles. *a*, The pipe-cross turning handle. This outfit is usually used in the Philippine Islands for general distribution because it is the least expensive satisfactory device we have tried. The only materials required are two pieces of pipe, a heavy cross or four-way joint, and a tool-steel pin to transfix the cross and shaft. The cross slides easily up or down the shaft; *b*, a turning handle for use on a shaft drilled with holes to engage the lugs. This wrench is more expensive than the pipe-cross handle.

6. Coupling and shaft. *a*, A solid coupling for shafts made in sections; two bolts are removed to take the shaft apart; *b*, the bolt shaft, one of the most useful shafts we have used. This shaft stands more rough use than any other shaft tried. Permanent bolts or rivets transfix the shaft at 3-foot intervals. The turning handles never damage this shaft. The bolt heads act as lugs for the handles to push against.

7. Turning handles. *a*, One type of locally made turning handle for the bolt shaft, hammered out by a blacksmith. These can also be made of cast iron; *b*, another type of locally made handle for the bolt shaft. The head of a bolt on the shaft enters the socket *r*, and the nut on the opposite end fits into notch *n*; *c*, a turning handle that can be made locally or purchased ready-made from dealers.

8. A more elaborate turning handle for use on the bolt shaft. This is an excellent handle but costs 20 pesos to make locally. In large quantities the cost should be less.

9. The A frame now used instead of a tripod for hoisting augers. The guy ropes are usually tied to a house, tree, or fence post. Bamboo is usually used because it is much cheaper in the Philippines than iron pipe.

10. In some places augers are lifted by direct pull, but the job is too heavy in most areas. The rope is attached to the arch or low down on the shaft.

11. Trap doors costing 6 pesos greatly facilitate boring. The auger shaft is supported by the doors when closed. Stakes can be driven into the earth at the notched corners to prevent movement of the platform while turning. One of these platform braces is now included as standard equipment with every auger used in the Philippines.

FIG. 12. This tripod is more difficult to transport than the A frames, but if properly made greatly speeds up boring when several holes are to be bored within a small area. *a*, Shaft support. A knock on the extension lever *c* releases the auger so that it can be swung away to be emptied; *b*, an iron hook that is a great time and energy saver. These hooks hold the auger away from the latrine while being emptied. The hooks are also used on A frames.

13. An excellent shaft brace designed by Doctor Hamilton. The cost of production is a disadvantage of this device. (Drawing from Doctor Hamilton's sketch.)
14. A quadruple expansion brace sold by the Alsdorf Corporation. The stock size is made to fit the Standard earth auger.
15. A locally made swivel for use on the top of the shaft. We have used these swivels but prefer unhooking the rope from the shaft while turning the auger.
16. Devices which can be attached to the auger shaft and adjusted to any position so that a hook on the hoisting rope can be quickly hooked on instead of tying and undoing knots; *a* and *b* are used on shafts with holes drilled at intervals such as used with the pipe-cross handles; *c* and *d* are used on the plain or bolt shafts.
17. Reamer, stone hooks, and grapple. *a*, An undercutting reamer which is useful in cutting away the sides of latrines below linings; fortunately it is rarely necessary to use one of these; *b* and *c*, stone hooks which are useful in removing small bowlders; *d*, a grapple (redrawn from picture from R. R. Howell & Co.).
18. Augers suitable for soft mud and silting sand. *a*, Type made by many manufacturers of drilling equipment; *b*, a heavy dumping auger such as used with machine-driven outfits; this auger is made by the Gus Pech Co.; *c*, the Lang auger with sand-boring screw; this is a good hand auger for boring in sand. See fig. 31, Howell drop-bottom auger.
19. Sand pumps and bailers which can be purchased from dealers. These pictures are from the Keystone Drilling Co., Beaver Falls, Pa.
20. The Iwan post-hole auger fitted with valves for use in silting sand.
21. A hinge to facilitate turning an auger over so that it can be dumped.
22. A hinge to facilitate turning an auger over so that it can be dumped.
23. A hinge for the same purpose as those shown in figs. 21 and 22.
24. An auger designed by A. L. Savignac for the United Fruit Co. This auger works in soft mud. Note the hinge for dumping.
25. A clay and sand auger that can be made locally. Augers of similar design are sold by many manufacturers without the flap valve *a*. R. R. Howell & Co., Minneapolis, manufacture these augers. A hinge on the shaft is not needed because the bottom of the auger swings back on a hinge to empty the contents.

FIG. 26. A valve auger designed by Doctor Hamilton in Java.

27. A short chisel-bottom bailer designed by the engineering department, Sarawak Oil Field, Ltd., Miri, Sarawak. This drill should be a good one, but is expensive to make and requires six men to handle effectively.

28. Disc augers. These are probably the cheapest augers made, but are not as good as other augers mentioned.

29. The Standard auger, sold by the A. J. Alsdorf Corporation.

30. The Lang-London, Ltd., auger. This auger is used in many places in clay and especially in soft sand. When used in sand a special screw, shown in fig. 18, *c*, is attached.

31. Various earth augers manufactured by R. R. Howell & Co. *a*, For clay and hard pan; *b*, for boring and removing core; *c* and *d*, for general boring; *e*, for loosening and removing stones; *f*, for loose sand soil; *g*, a drop-bottom, fast-cutting auger especially useful with power-driven machines; *h*, a spudding jetting drill used in rock drilling. Blasting is much more rapid for latrine installation in rock.

32. Animal-driven boring apparatus. Used for many years in well drilling, but not suitable for rapid latrine boring.

33. The Budda-Hubron machine drill. This is an efficient rotary drill, and takes less operating space than any machine we have heard of. It can be used for boring in clay, sand, hard pan, shale, and frozen ground. The stock machine bores holes 10 feet in depth, but the manufacturers will equip it for boring 20-foot holes. It costs about 2,400 dollars United States currency.

34. The Gus Pech power-driven machine is a rapid borer, but requires a space 10 by 16 feet for efficient operation. It costs less than 1,000 dollars equipped for latrine boring.

35. Tools used for blasting latrines in rock. *a*, Bar used in drilling blast holes in tuff, adobe rock, and other hard formations; *a 3*, drill used with hammer for making blast holes in hard rock; *b*, crow bar used for starting latrine or straightening side; *c*, long bar used occasionally in deep latrines; *d*, bamboo bucket for removing water from blast holes; *e*, bamboo brush for cleaning mud out of blast holes.

36. Blasting in rock. *a* to *e*, Positions of blast holes. In hard rock five blast holes are drilled at *a* and *b*.

37. A hand drill especially designed for making blast holes in tuff, adobe rock, shale, or other hard formations. It will not cut hard rock. This drill cuts the holes rapidly and cleans them out at the same time; it is constantly used now in place of the bar *a*, fig. 35, except in the hardest rock where the drill *a*3 is used. Manufactured by the Howells Mining Drill Co., Plymouth, Pa. Cost about 18 dollars.

38. A geared drill for boring blast holes rapidly in very hard formation except hard rock. Manufactured by Howells Mining Drill Co., Plymouth, Pa. Cost, 140 dollars.

FIG. 39. Derrick manufactured by Werf Conrad, Haarlem, Holland. For rotary, percussion, or free-ball system of boring. This apparatus will handle heavy drills. It is too heavy for general bored-latrine work.

40. Hand-power spudding and hoisting windlass manufactured by Werf Conrad, Haarlem, Holland. Believed to be too expensive (about 200 dollars) and too bulky for general distribution for latrine boring.

41. Woven-bamboo cylinder partly made. This makes a very satisfactory latrine lining in most places. The section *a* is a temporary support to keep the ribs straight while weaving; *b* is an enlarged section of the woven-bamboo latrine lining.

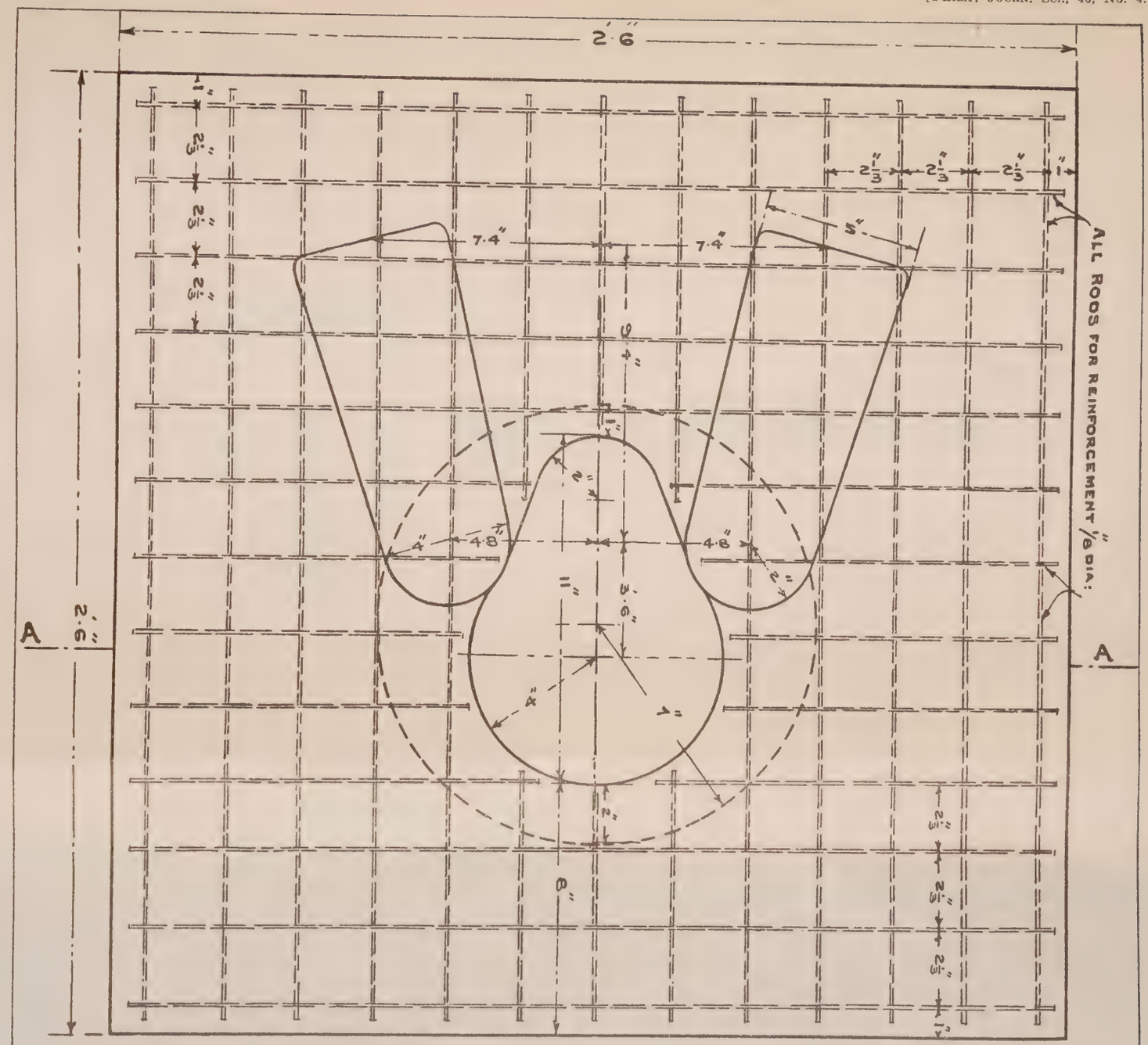
42. Various latrine linings. *a*, A galvanized-iron wire-net lining which can be used in places where white ants eat the bamboo or where bamboo is not available; *b*, stove-pipe double wall, "wall method" of making a lining. In ordinary soils numerous holes can be cut into the metal to allow better action. In silting soils the sections are added one at a time as boring proceeds. A few dents hold the cylinders together; *c*, four to six empty metal oil or tar drums placed end on end are frequently used as linings for latrines. The heads of the drums are cut out with a chisel. Wooden or metal strips are nailed to the drums to make strong joints. These are often used in silting sand.

43. A steel latrine floor, or squatting plate, designed by Dr. W. P. Jacocks for use in Ceylon. The cost is about 4 rupees, about 2.60 pesos.

44. Latrine and water closet. *a*, The bored-hole latrine complete with superstructure. The lining and cement casing are not used in soil that does not cave into the latrine. Metal drums are usually used instead of cement casings where the water rises to the surface; *b*, a cement water closet that can be flushed with a bucket of water. About two hundred of these water traps are giving excellent service in the Philippines. Note clean-out hole in Plate 3. The sloping foot rests make the user sit on the water closet correctly. The rests throw one off balance if he attempts to squat backwards. These traps cost about 4 pesos each. They absolutely eliminate fly and mosquito breeding and foul odors.

45. Reënforced concrete slab for use with water trap. Elevated type.

46. Latrine equipped with water trap sunk flush with the slab. This trap costs only 3 pesos. Note the sloping foot rests and the small vent, which can be opened to relieve pressure in an air-tight latrine. The washings from the trap fall from the lip and do not follow the trap down to the wall of the latrine.



PLAN

CROSS SECTION ON A.A

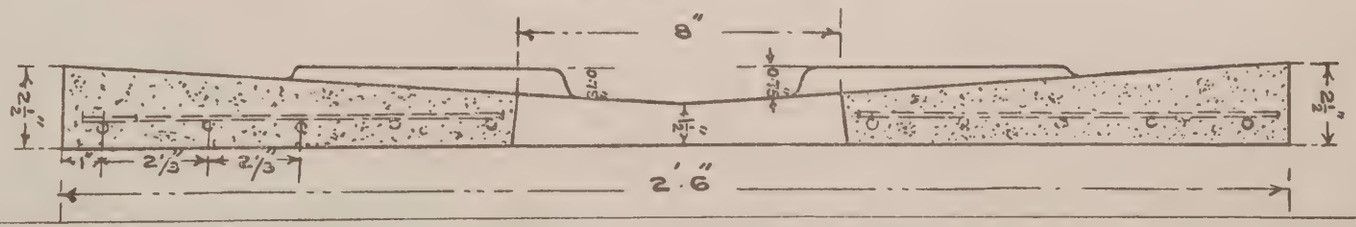


PLATE 1.

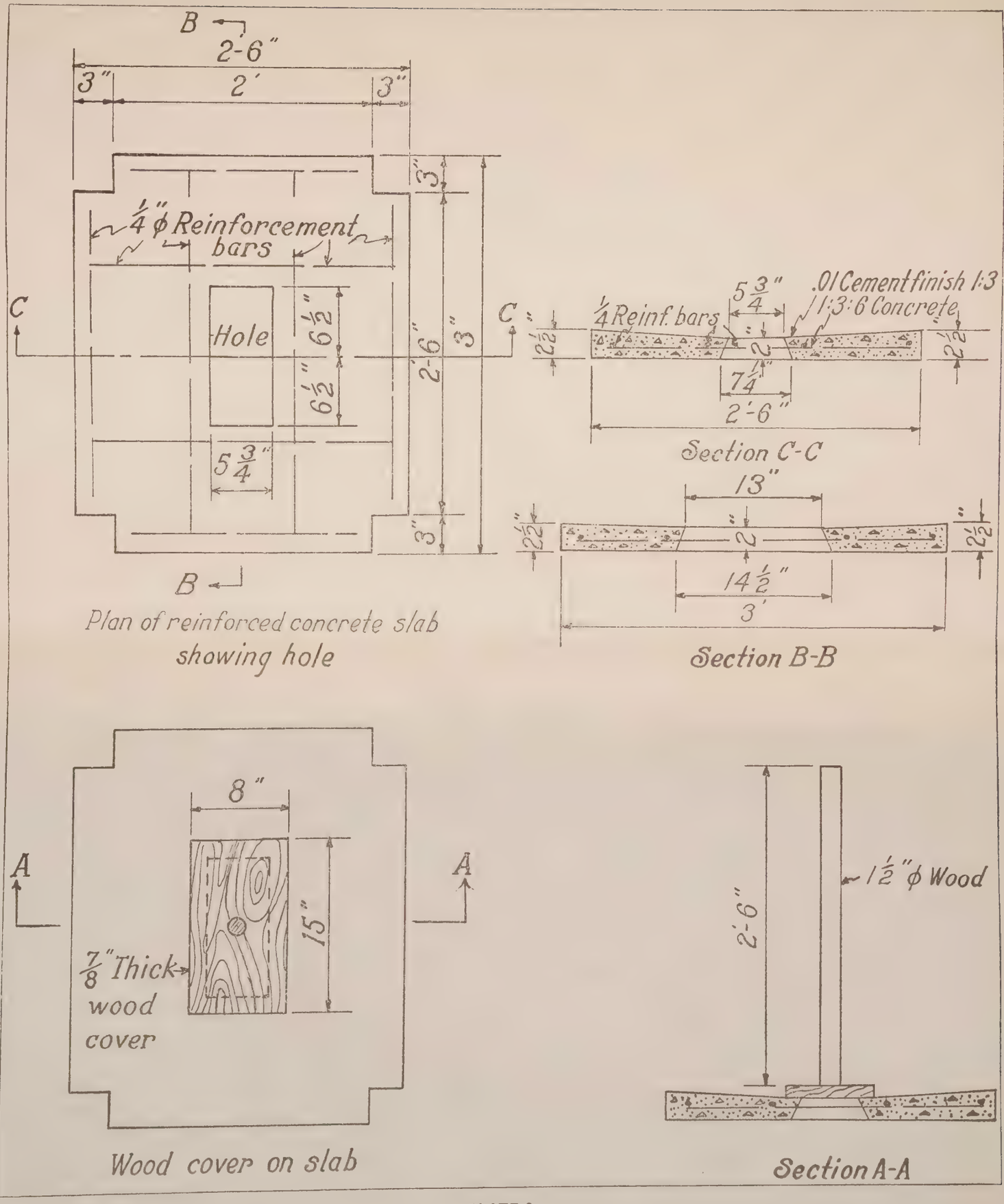

B
2-6"
3"
2'
3"
3"
¼" ϕ Reinforcement bars
C
Hole
6½"
6½"
2'-6"
3"
C
3"
5¾"
B
Plan of reinforced concrete slab showing hole
¼ Reinf. bars
5¾"
.01 Cement finish 1:3
1:3:6 Concrete
2½"
2"
2½"
7¼"
2'-6"
Section C-C
13"
2½"
2
2½"
14½"
3'
Section B-B
A
8"
A
15"
⅞" Thick wood cover
Wood cover on slab
1½" ϕ Wood
2'-6"
Section A-A

PLATE 2.

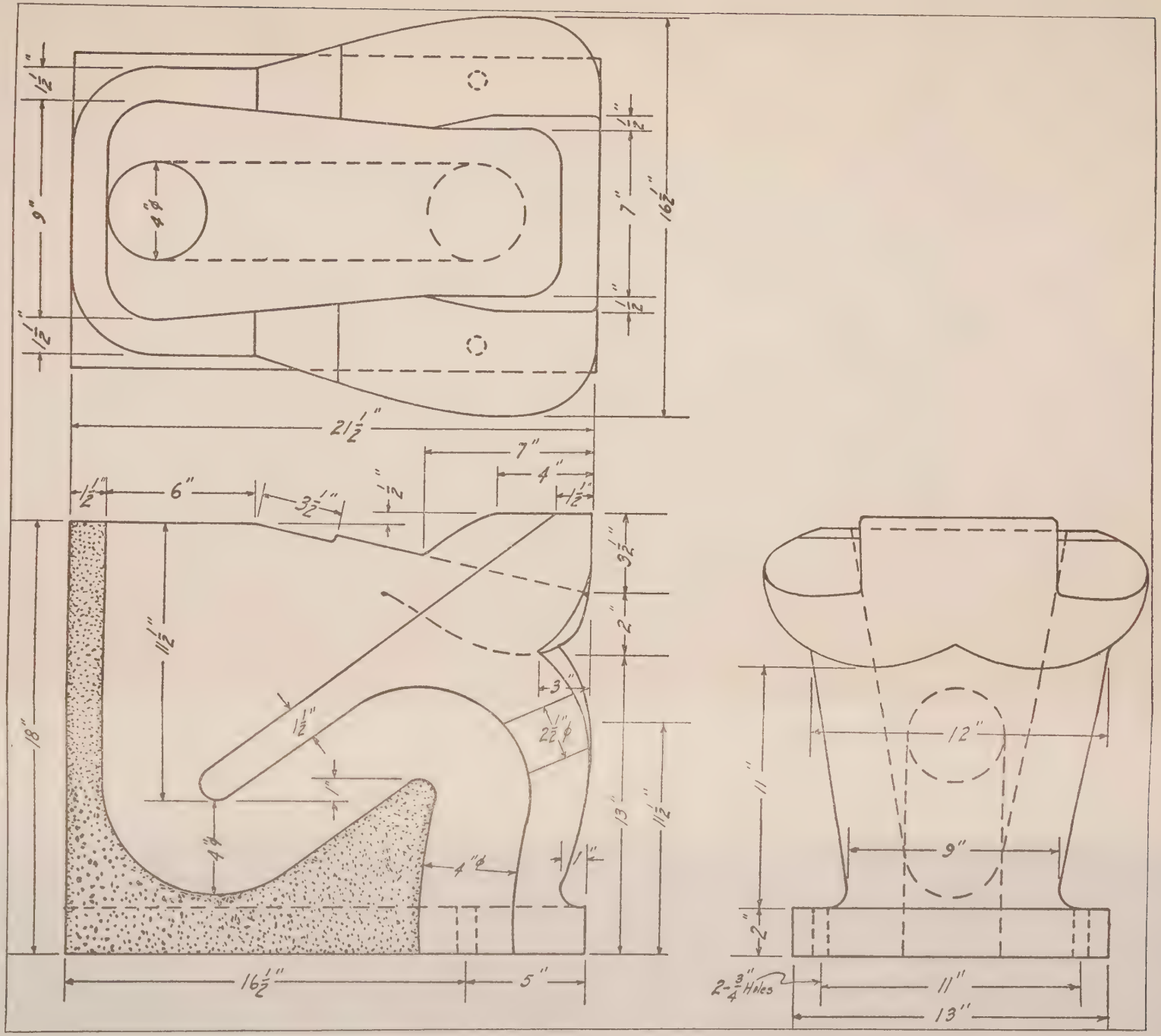

1"
1½"
9"
1½"
4"ϕ
1"
1½"
7"
16½"
21½"
7"
4"
1½"
1½"
6"
3½"
1½"
3½"
2"
11½"
18"
3"
1½"
2½"ϕ
1"
4"
4"ϕ
1"
13"
11½"
16½"
5"
12"
11"
9"
2"
2-¾" Holes
11"
13"

PLATE 3.

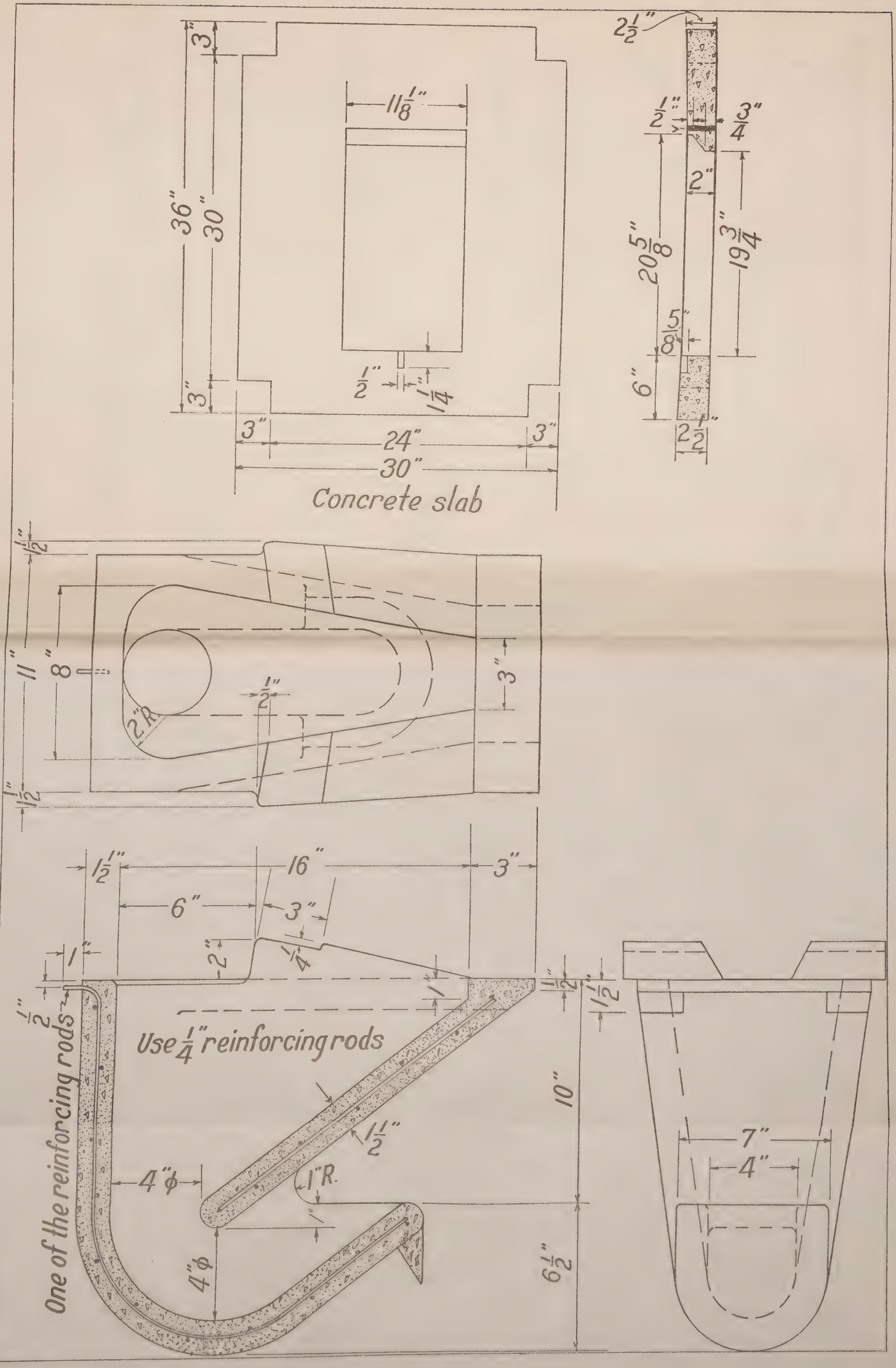

3"
36"
30"
3"
11/8"
1/2"
1 1/4"
3"
24"
3"
30"
Concrete slab
2 1/2"
1/2"
3/4"
2"
20 5/8"
3"
19 3/4"
5/8"
6"
2 1/2"
1 1/2"
11"
8"
2"R
1/2"
3"
1 1/2"
1 1/2"
16"
3"
6"
3"
1"
2"
1/4"
1"
1 1/2"
1 1/2"
Use 1/4" reinforcing rods
One of the reinforcing rods
10"
1 1/2"
4"ϕ
1"R.
1"
4"ϕ
6 1/2"
7"
4"

PLATE 4.

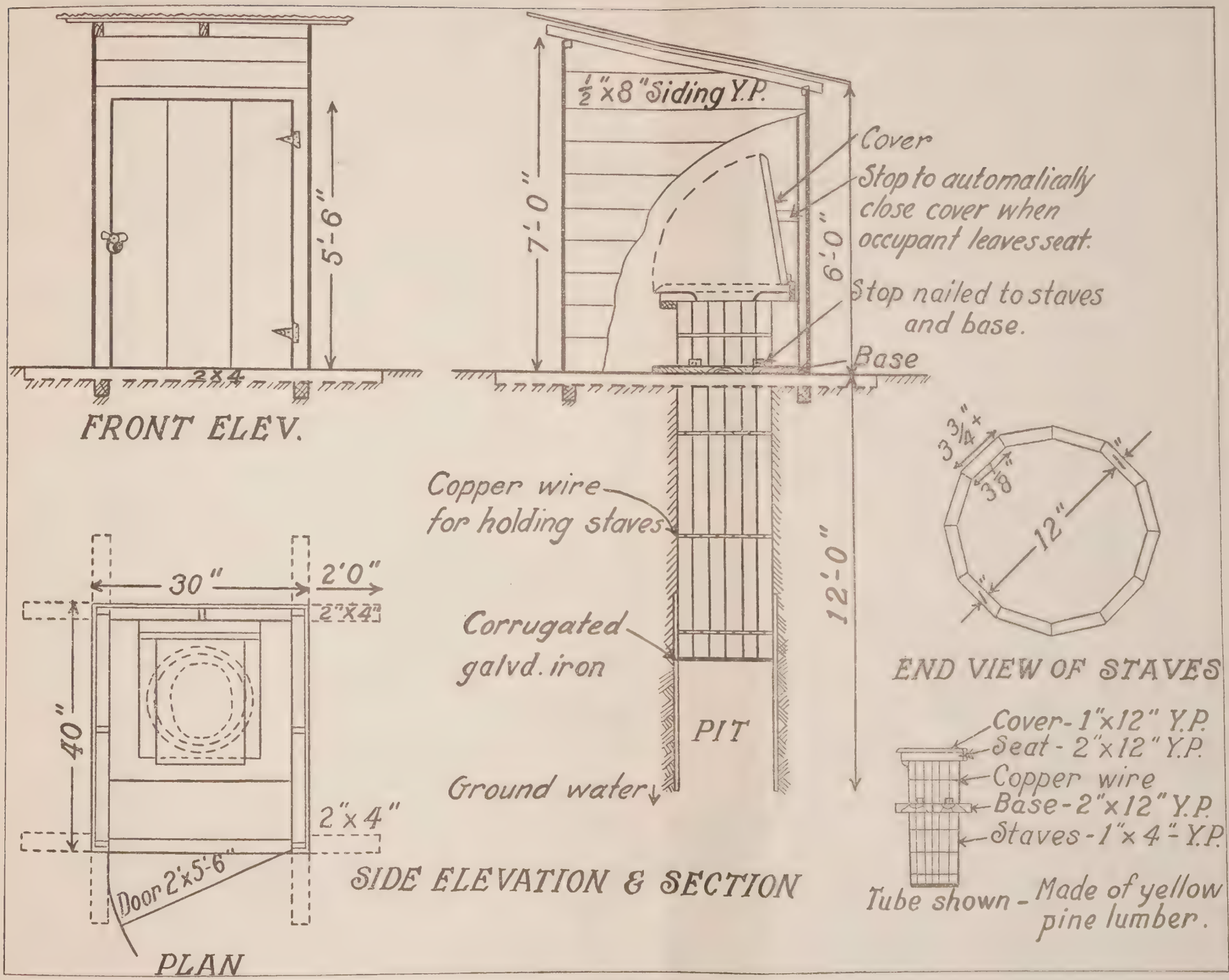

5'-6"
2×4
FRONT ELEV.
½"×8" Siding Y.P.
7'-0"
6'-0"
Cover
Stop to automatically close cover when occupant leaves seat.
Stop nailed to staves and base.
Base
Copper wire for holding staves
Corrugated galvd. iron
PIT
12'-0"
Ground water
3 3/4"
3 1/8"
12"
END VIEW OF STAVES
30"
2'0"
2"×4"
40"
2"×4"
Door 2'×5'-6"
PLAN
SIDE ELEVATION & SECTION
Cover - 1"×12" Y.P.
Seat - 2"×12" Y.P.
Copper wire
Base - 2"×12" Y.P.
Staves - 1"×4" Y.P.
Tube shown - Made of yellow pine lumber.

PLATE 5.

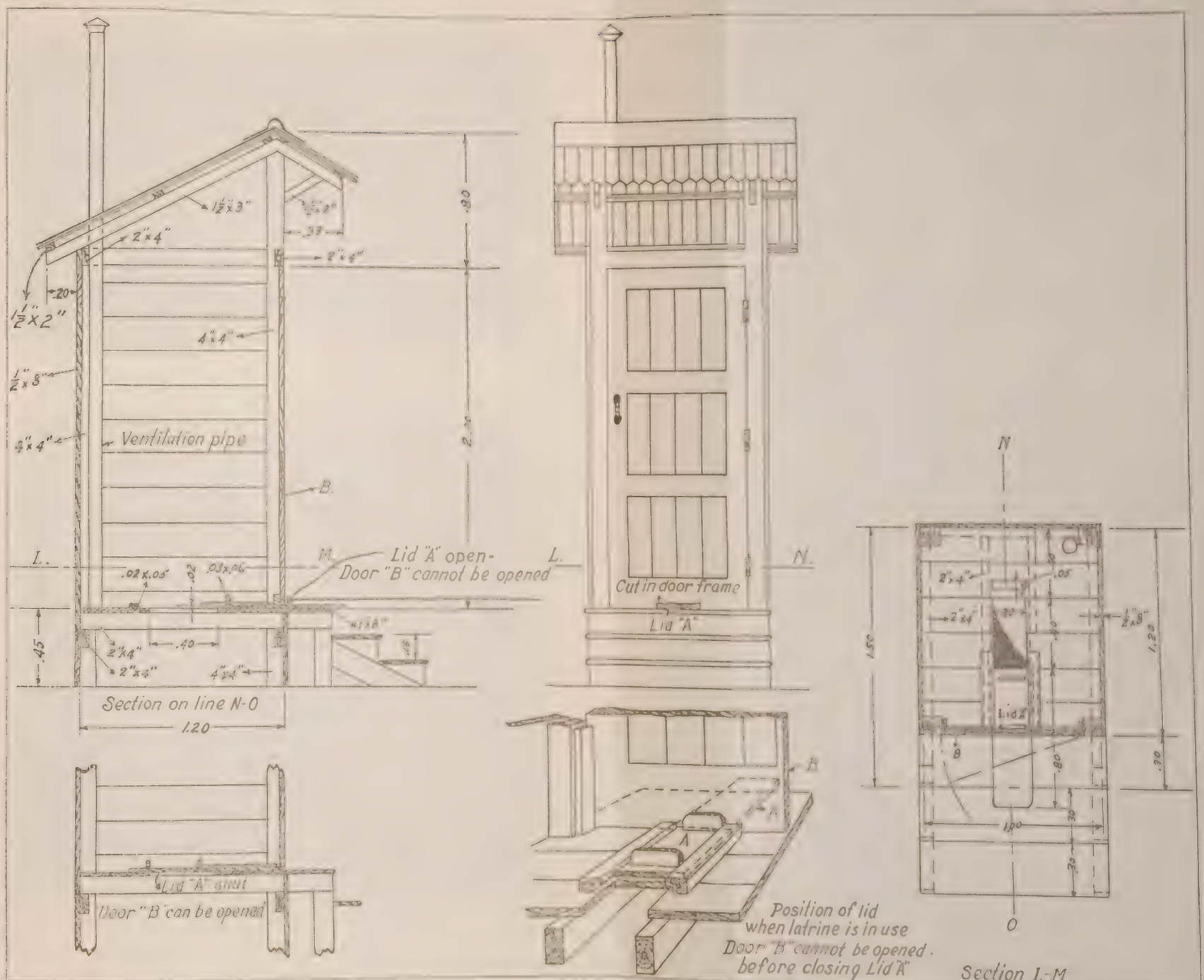
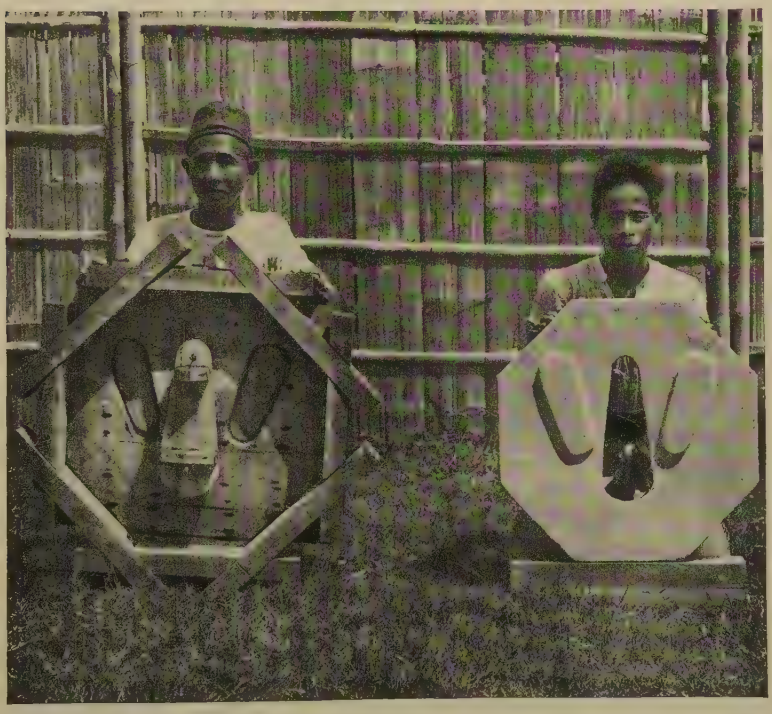

1½"x3"
2"x4"
1½"x2"
4"x4"
1"x8"
Ventilation pipe
B.
L.
M.
Lid "A" open-
Door "B" cannot be opened
.02x.05
.03x.06
2"x4"
4"x4"
Section on line N-O
1.20
Lid "A" shut
Door "B" can be opened
Cut in door frame
Lid "A"
N.
Position of lid
when latrine is in use
Door "B" cannot be opened
before closing Lid "A"
N
O
Lid A
Section L-M

PLATE 6.

1



2

PLATE 7.

THE PHILIPPINE VARIETIES OF ANOPHELES GIGAS AND ANOPHELES LINDESAYI

By W. V. KING

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TWO PLATES

Anopheles formosus was described by Miss Ludlow in 1909 from a specimen collected at Camp John Hay, Baguio, Benguet, on Luzon Island. It was later considered by Christophers to be a variety of *Anopheles gigas* Giles. The species has not since been reported from the Philippines and the larva has not previously been described. The following description of this stage is based on an examination of 35 larvæ collected in the same locality in April and May, 1929, and in May, 1931. One of the three collections, that of May, 1929, was made for me by Sergeant J. F. Rhodes, of the United States Army Medical Corps. The larvæ were taken at an altitude of about 4,700 feet.

ANOPHELES GIGAS var. FORMOSUS Ludlow, 1909.

Larva.—Inner anterior clypeal hairs (Plate 1, fig. 1) usually simple but occasionally split into two, the bases close together; the outer clypeal hairs one-half or more the length of the inner and branched two to six times, sometimes simple; posterior clypeal hairs nearly as long as the outer and somewhat closer together, branched toward the base from three to eight times, the usual number four or three. Occipital hairs large, the inner branched from four to twelve times, usually from eight to ten; the outer branched from seven to sixteen times with counts of nine, ten, or eleven the most frequent. Inner anterior submedian thoracic hair with three to ten branches; middle anterior hair much longer with from eight to fifteen branches (Plate 1, fig. 3). Palmate hairs lacking on the thorax and first two abdominal segments, being represented by ordinary branched hairs, the one on the thorax with four to ten branches (Plate

[1] In coöperation with the Bureau of Science and the Philippine Health Service.

1, fig. 5). Well-developed palmate hairs present on abdominal segments III to VII, the individual leaflets more or less bluntly tapered, without filaments, and either smooth or with a few serrations on the edges (Plate 1, fig. 7). All of the antipalmate hairs (hair 2 of Martini, 1923) multiple, those on segments III to VII having from three to eight branches with five the most frequent number; antipalmate hair on segment II with from four to eleven branches, seven and eight being the most frequent. The long lateral hairs on abdominal segments IV and V usually 3-branched but vary from two to five in the series; this hair lacking on segment VI and is represented by a very short, branched tuft. Pecten (one specimen) with six long and fifteen short teeth.

The larvæ were collected at the grassy margins of pools in stream beds and on one occasion along the edge of a large rock in a well-shaded stream pool.

Adult females reared from Baguio larvæ agree in general with Ludlow's original description except that the fringe spot on the posterior margin of the wing occurs between veins 5.2 and 6 instead of between the forks of the 5th vein as stated. The type specimen now in the United States National Museum in Washington has it in this position also so that the original description was in error.

The palpi have three very narrow white bands and the apex is more or less pale, some specimens having distinct yellowish scales, others only pale apical hairs. The 6th vein of the wing has a white scaled area two or three times the length of the apical dark spot, the subapical costal white spot is absent and the extreme base of the costa is white (Plate 2, fig. 1).

Slight differences in adult markings have been given for the several varieties of this species, and Christophers (1931) has recently published a revised summary of the group. The varieties recognized, are:

Anopheles gigas Giles, 1901, type form from southern India.
Var. *formosus* Ludlow, 1909, from Luzon, Philippine Islands (not Formosa as listed by Christophers).
Var. *simlensis* James, 1911, from the Western Himalayas.
Var. *refutans* Alcock, 1913, from Ceylon.
Var. *baileyi* Edwards, 1929, from Western China, Eastern Himalayas, Assam, Burma and Tibet.
(*Anopheles edwardsi* Yamada, 1924, from Japan, is considered a distinct species.)

The Philippine form appears, from palpal and wing markings, to resemble variety *refutans* more closely than any of the others.

Both have pale-tipped palpi and the wings are without fringe spots except in the area between veins 5.2 and 6. The two forms probably differ in the scaling of the extreme base of the costa, which Christophers shows to be dark scaled in variety *refutans*. He also records the occurrence of this character in variety *formosus*, but all Philippine specimens examined by me have a white scaled area at the extreme base of the costa, nearly equal to or longer than the succeeding (inner accessory) dark spot, as shown in the accompanying illustration.

The larval characters of the Ceylon form so far as given by Carter (1925) also appear to be similar to those of the Philippine variety except that the post-clypeal hairs are said to be simple or with two or three divisions, whereas none of the specimens examined in this series of var. *formosus* have hairs with less than three branches.

Male genitalia of var. formosus (Plate 2, figs. 3 and 5).— Inner parabasal spine of side piece broad and flattened for entire length, about 0.11 mm long; outer spine 0.14 mm long, more slender and tapered to a long point. Outer lobe of harpagones (claspette) with five to seven unfused spatulate filaments or blades, the internal one somewhat longer than the others, arising from a separate prominence. Length of latter 0.11 mm and the longest one of the others 0.09 mm. The individual blades are bluntly rounded and end in a minute thornlike point. On the inner lobe of the harpagones a group of three hairs placed close together, the outer 0.09 mm long, the middle one very short and the inner one, at the apex of the lobe, 0.14 mm long. In one of three specimens examined, the middle hair on one side is also long. Mesosome (theca) with five to seven leaflets, the longest one about 0.05 mm, the others progressively shorter. Under high magnification most of the leaflets show serrations. The ventral processes of the 9th segment are not apparent except possibly as small humps.

The genitalia of the Philippine variety appear to differ slightly from that of *A. gigas* as described by Christophers (1915) in the hairs of the harpagones and in the ventral processes of the 9th segment.

ANOPHELES LINDESAYI var. BENGUETENSIS var. nov.

A collection made for me by Sergeant Rhodes at Camp John Hay in May, 1929, contained, in addition to larvæ of *A. maculatus* and *A. gigas* var. *formosus*, several specimens of this species, which is the first record of its occurrence in the Philippines. Sergeant Rhodes said that the larvæ were collected along the

edge of a well-shaded stream among leaves and débris or at the side of rocks. Additional collections in the same locality have been made by Mr. F. E. Baisas during 1930 and by myself in May, 1931.

Adults of *A. lindesayi* have unbanded palpi and tarsi and are readily identified by the presence of a broad white band on the distal half of the hind femora. The wing markings of the female of the Philippine variety are shown in the accompanying illustration (Plate 2, fig. 2). The white-scaled spots at the tips of veins 4.2, 5.2, and 6 and the fringe spot at 5.2 are evidently constant, being present in each of the seventeen specimens examined. No white scales occur at the ends of veins 2.2, 3, 4.1, or 5.1. The wing fringe opposite veins 6 and 4.2 is variable and may be either dark or slightly pale.

The markings of the wing are therefore slightly different from any of the varieties of this species as listed by Christophers (1931). The forms recognized by him are:

A. lindesayi[2] Giles, 1900, type form, from the Himalayas.
Var. *japonicus* Yamada, 1918, from Japan.
Var. *pleccau* Koidzumi, 1920, from Formosa (provisionally retained).
Var. *nilgiricus* Christophers, 1924, from South India.
Var. *cameronensis* Edwards, 1929, from the Federated Malay States.

The Philippine form probably comes closest to var. *japonicus*. The scaling at the termination of the veins in the latter variety is, however, considerably more variable. Yamada (1924) notes the occurrence of white spots at the ends of veins 3, 4.2, 5.1, 5.2, and 6 and adds that those at 3, 4.2, and 5.1 may or may not appear according to the specimens. Fringe spots also may or may not occur opposite veins 4.2, 5.1, and 5.2.

The fore and mid femora of the Philippine specimens have distinct white bands or rings at the base, equal to or less than the diameter of the femora in extent. The bands on the hind femora are variable but usually wider. In a number of specimens the ventral white is two to three times the diameter of the femoral joint and the dorsal white somewhat shortened (one to two times the diameter.) In certain specimens the white is practically the same above and below, while in two specimens the black scaling extends nearly to the base above and the white scaling ventrally is more extensive—between one-fifth and one-sixth of the length of the femora by measurement in one speci-

[2] Named after Captain Lindesay but originally spelled *lindesaii*. The changed spelling followed here was made, I believe, by Blanchard in 1905.

men. The arrangement of white seems to be more of less similar to that of var. *cameronensis*, but, according to Christophers, that form has none of the wing veins from 2.2 to 5.2 white-tipped.

Male genitalia.—Inner parabasal spines stout, flattened and recurved, 0.10 mm long (one measurement); outer stout and somewhat flattened toward end, 0.14 mm long. Outer lobe of harpagones with three bladelike filaments subequal in length and broadest near tip, the longest about 0.07 mm; inner lobe with a stout hair at apex, 0.10 mm long, and well separated from this internally a slenderer hair, 0.07 mm long (Plate 2, fig. 6). Mesosome with very many slender leaflets (Plate 2, fig. 4), eighteen or nineteen on each side in three specimens, counted after separating the mesosome from the hypopygium and flattening under a cover glass. Some of the leaflets are serrated along the side and some are split at the tip.

The harpagones of *A. lindesayi* as described by Christophers (1915) have two bladelike spines on the outer lobes, instead of three, and a much smaller number of leaflets on the mesosome—about five as compared to eighteen or so in var. *benguetensis*.

Larva.—The characters recorded for one of the larvæ from the original collection are as follows: Inner anterior clypeal hairs long, simple and close together; outer clypeals simple, less than half the length of the inner; postclypeals about as long and as widely separated as the outer, two branches on one side and three on the other (Plate 1, fig. 2). Inner occipital hairs simple on one side, forked on the other; outer occipitals three and four branched. Inner anterior submedian thoracic hairs (Plate 1, fig. 4) with thirteen and fourteen branches; middle hairs longer, with fourteen and twenty branches. Thoracic palmate tuft developed, the leaflets being slenderer than those on the abdomen (Plate 1, fig. 6); abdominal palmate tufts developed on segments II to VII, the leaflets with filaments (Plate 1, fig. 8). The lateral hairs on abdominal segment IV, three branched, on segment V, three and two branched and absent on segment VI.

From other specimens collected and examined by Mr. Baisas, the postclypeal hairs are sometimes simple, although two or three divisions is the usual number. The antipalmate hairs on segment II have about six branches; on segment III usually five or six; on segments IV and V, single; on segment VI usually three and on segment VII, five.

The larvæ are pigmented and mottled on the dorsal surface of the thorax and abdomen, and wide pigmented bands completely

surround abdominal segments II, IV, VI, VII, and VIII, giving the larvæ a characteristically striped appearance and distinguishing them from other species with which they occur. The banding still appears after preservation in formalin.

Type female reared from larva collected at Baguio, Benguet Subprovince, Luzon, Philippine Islands, May 20, 1931. Taken at an altitude of about 4,700 feet.

REFERENCES

ALCOCK, A. Synopsis of the anopheline mosquitoes of Africa and of the Oriental region. Journ. Lond. Sch. Trop. Med. 2 (1913) 153–166.

CARTER, H. F. The anopheline mosquitoes of Ceylon. Part I. The differential characters of the adults and larvæ. Ceylon Journ. Sci. § D, Med. Sci. 1 pt. 2 (1925).

CHRISTOPHERS, S. R. The male genitalia of Anopheles. Ind. Journ. Med. Res. 3 (1915) 371–394.

CHRISTOPHERS, S. R. Some Himalayan and Peninsular varieties of Indian species of Anopheles. Ind. Journ. Med. Res. 12 (1924) 11–13.

CHRISTOPHERS, S. R. Studies on the anopheline fauna of India. (Parts I-IV). Recds. Mal. Surv. Ind. 2, No. 2 (1931) 305–332.

GILES, G. M. Handbook of the Gnats or Mosquitoes. 1st. ed. (1900).

GILES, G. M. Descriptions of four new species of Anopheles from India. Ent. Month. Mag. 2d ser. 12 (1901) 196–198.

JAMES, S. P., in James and Liston. A monograph of the Anopheline mosquitoes of India, 2d ed. (1911).

KOIDZUMI, M. Daiwan Kenkyujo Hokoku 8 (1920) 17, 28, and 34. (Cited by Yamada, 1924.)

LUDLOW, C. S. Mosquito comment. Canad. Ent. 41 (1909) 22.

MARTINI, E. Uber einige für des System bedentungsvolle Merkmale der Stechmüchen. Zool. Jahr., Abt. für Syst. Geo. Biol. der Tiere, 46 (1923) 517–590.

YAMADA, S. Eiseigaku Densenbyogaku Zasshi 13 (1918) 689. (Cited by Yamada, 1924.)

YAMADA, S. A revision of the adult anopheline mosquitoes of Japan. Sci. Rept. Govt. Inst. Inf. Dis. 3 (1924) 215–241.

ILLUSTRATIONS

[The illustrations are from camera lucida drawings made by F. E. Baisas and F. del Rosario.]

PLATE 1

FIG. 1. Clypeal hairs of *A. gigas* var. *formosus*.
2. Clypeal hairs of *A. lindesayi* var. *benguetensis*.
3. Anterior submedian thoracic hairs, left side, of var. *formosus*.
4. Anterior submedian thoracic hairs, right side, of var. *benguetensis*.
5. Branched hair in place of thoracic palmate of var. *formosus*.
6. Thoracic palmate of var. *benguetensis*.
7. Two leaflets from an abdominal palmate tuft, segment IV of var. *formosus*.
8. Two leaflets from an abdominal palmate tuft, segment IV of var. *benguetensis*.

PLATE 2

FIG. 1. Wing of var. *formosus*.
2. Wing of var. *benguetensis*.
3. The leaflets from one side of the mesosome of the male genitalia of var. *formosus*.
4. The leaflets from one side of the mesosome of var. *benguetensis*.
5. Half of the harpagones of var. *formosus*.
6. Half of the harpagones of var. *benguetensis*.

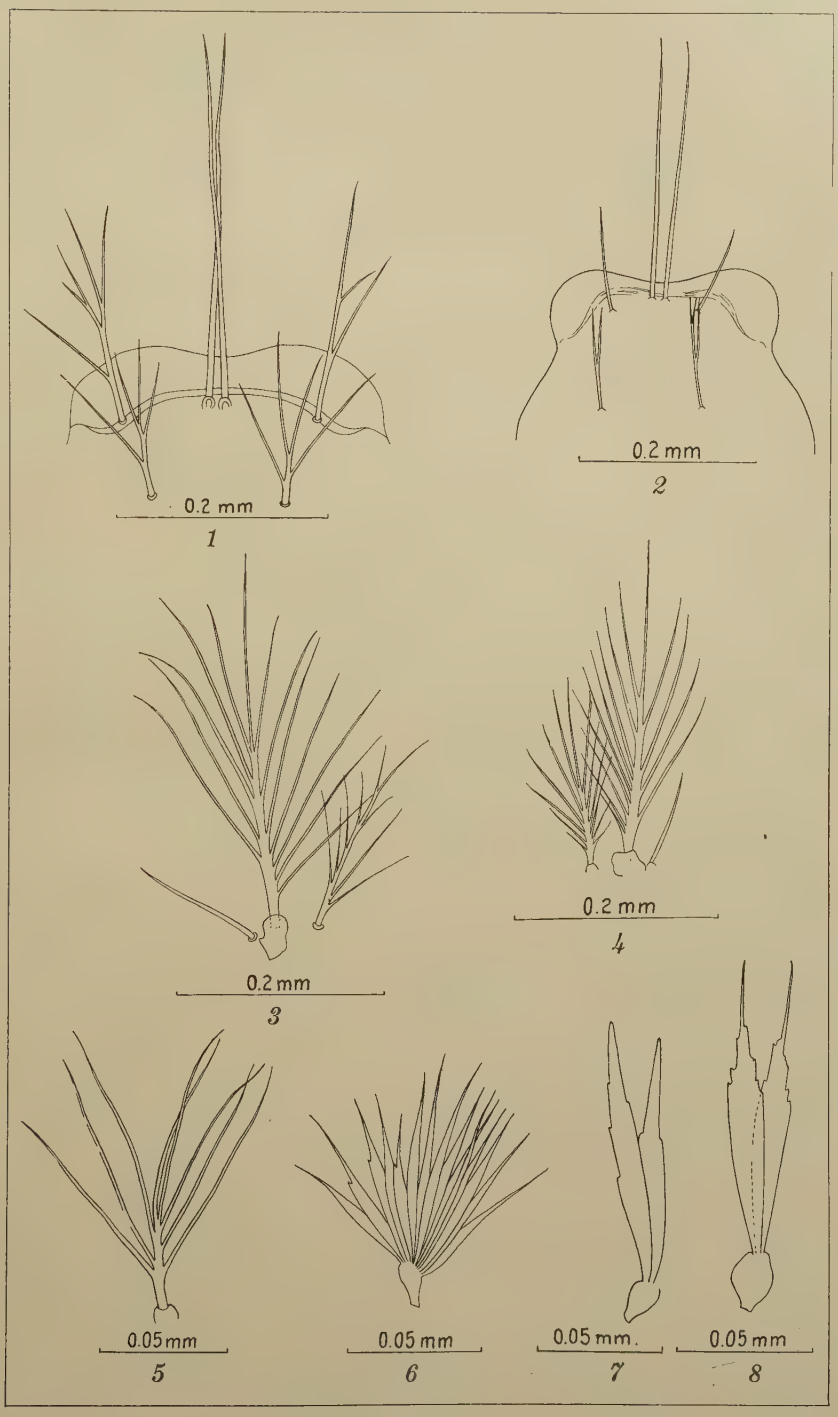

PLATE 1.

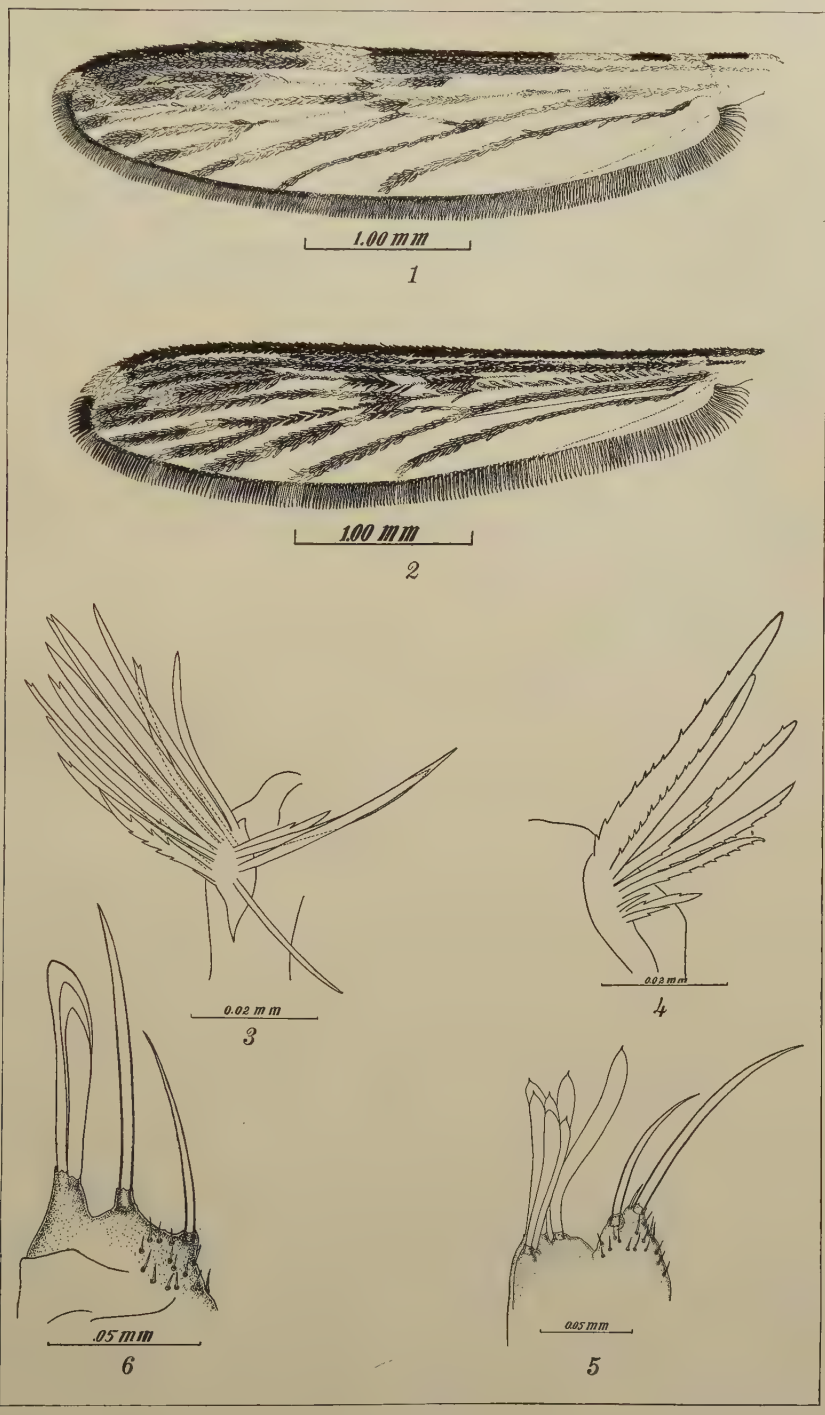

PLATE 2.

THE USE OF THE ANTENNÆ AS A MEANS OF DETERMINING THE SEXES IN LEUCOPHOLIS IRRORATA ADULTS (COLEOPTERA, SCARABÆIDÆ)[1]

By A. W. Lopez

Chief Entomologist, Research Bureau, Philippine Sugar Association

ONE PLATE

INTRODUCTION

The flying season of *Leucopholis irrorata* beetles in Occidental Negros normally occurs during the latter part of April, all of May, and the first part of June.

During the season of 1930, this entomology department examined 1,663 beetles in order to determine the sex ratio and the egg content of beetles collected in the field, for the purpose of securing data on the soundness of the collecting campaign principle. Because neither the writer nor other local entomologists could differentiate between the sexes at sight, it was necessary to dissect every individual in order to determine its sex, with a consequent expenditure of a great amount of time.

At the start of the 1931 season it became apparent to the writer that males could be separated from females through certain characteristics inherent in the antennæ. It is now possible to take a group of beetles on which data are desired, and rapidly and accurately to pick out the males and females. The former may then be counted, and only the females dissected. This differentiation cannot be practiced immediately, but a small amount of practice will enable one to so differentiate rapidly.

MATERIAL AND METHODS

One antenna and the elytron from the same side were removed from a live *L. irrorata* beetle, and the club of the former and the total length of the latter were measured with a stage micrometer to one-tenth of a millimeter. An assistant then dissected the

[1] The most important sugar-cane white grub (buc-an) of the Philippines.

beetle positively to determine its sex. One hundred antennal clubs and elytra were so measured for each sex.

In making the drawings of the extended antennal clubs, some difficulty was encountered because they immediately became compact when the antennæ were severed. Submersion in 80 per cent alcohol or concentrated acetic acid for a short time caused them to extend themselves in approximately the normal manner. The drawings were made with the aid of a camera lucida.

THE DIFFERENTIATION OF THE SEXES

The length of the male antennal club (Plate 1, fig. 2) as deduced from the measurement of one hundred individuals, averages 1.87 millimeters ± 0.0076 millimeter [2] and the female antennal club Plate 1, fig. 1) averages 1.3 millimeters ± 0.0073 millimeter, the male antennal club being approximately 0.57 millimeter longer than that of the female. While the difference is not great it is readily perceptible to the naked eye.

The elytra were measured in order to ascertain whether or not the size of the beetle had an appreciable influence on the length of the antennal club. If the size of the beetle should influence the size of the club, then a female that happened to be larger than a male would have a longer club and the differentiation could not be made. A summary of the results of the measurement of the clubs and of the elytra, which are considered indicators of the size of the beetle, is shown in Table 1.

TABLE 1.—*Showing summary of results of club and elytra measurements in Leucopholis irrorata.*

	Average length in 100 individuals.		Sizes.			
	Elytron.	Antennal club.	Shortest elytron.	Antennal club.	Longest elytron.	Antennal club.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Male	18.3±0.0494	1.87±0.0076	16.5	1.8	19.6	1.9
Female	18.9±0.0615	1.3±0.0073	16.4	1.2	21.0	1.4

In Table 1, the female elytron is shown to be approximately 0.6 millimeter longer than that of the male, while the antennal club is approximately 0.57 millimeter shorter than that of the male, as mentioned above. It may also be noted in the table that the male beetle with the shortest elytron had a club about

[2] Probable error for the mean.

0.07 millimeter shorter than the average, and that the male with the longest elytron had a club about 0.1 millimeter longer than the average. In the females there is only a difference of about 0.1 millimeter in the length of the antennal club either way from the average in the beetle with the shortest and in the one with the longest elytron. It is thus seen that the size of the beetle apparently does not influence the length of the antennal club to any appreciable extent.

In addition to making the differentiation between the sexes by the difference in length of the antennal clubs alone, the difference in the contour between the posterior edges of the male and female extended antennal clubs can also be made use of.

In the female extended antennal club (Plate 1, fig. 3) at point *a*, the posterior edges of the first two lamellæ form nearly a smooth curve with the last funicular segment (Plate 1, fig. 1, *f*), while in the male (Plate 1, fig. 4) at point *a*, the posterior edges of the first two lamellæ do not form a smooth curve with the last funicular segment, but a distinct drop is noticed, giving the male extended club a characteristic appearance different from that of the female extended club.

The males and females of *Lepidiota pruinosa* may be separated in a manner identical with the above.

264209——15

ILLUSTRATION

[*a*, Reference point; *c*, club; *f*, funicle; *l*, lamellæ; *p*, pedicel; *s*, scape.]

PLATE 1

FIG. 1. Right antenna of female *Leucopholis irrorata*, × 30.
2. Right antenna of male *L. irrorata*, × 30.
3. Extended right antennal club of female *L. irrorata*, × 30.
4. Extended right antennal club of male *L. irrorata*, × 30.

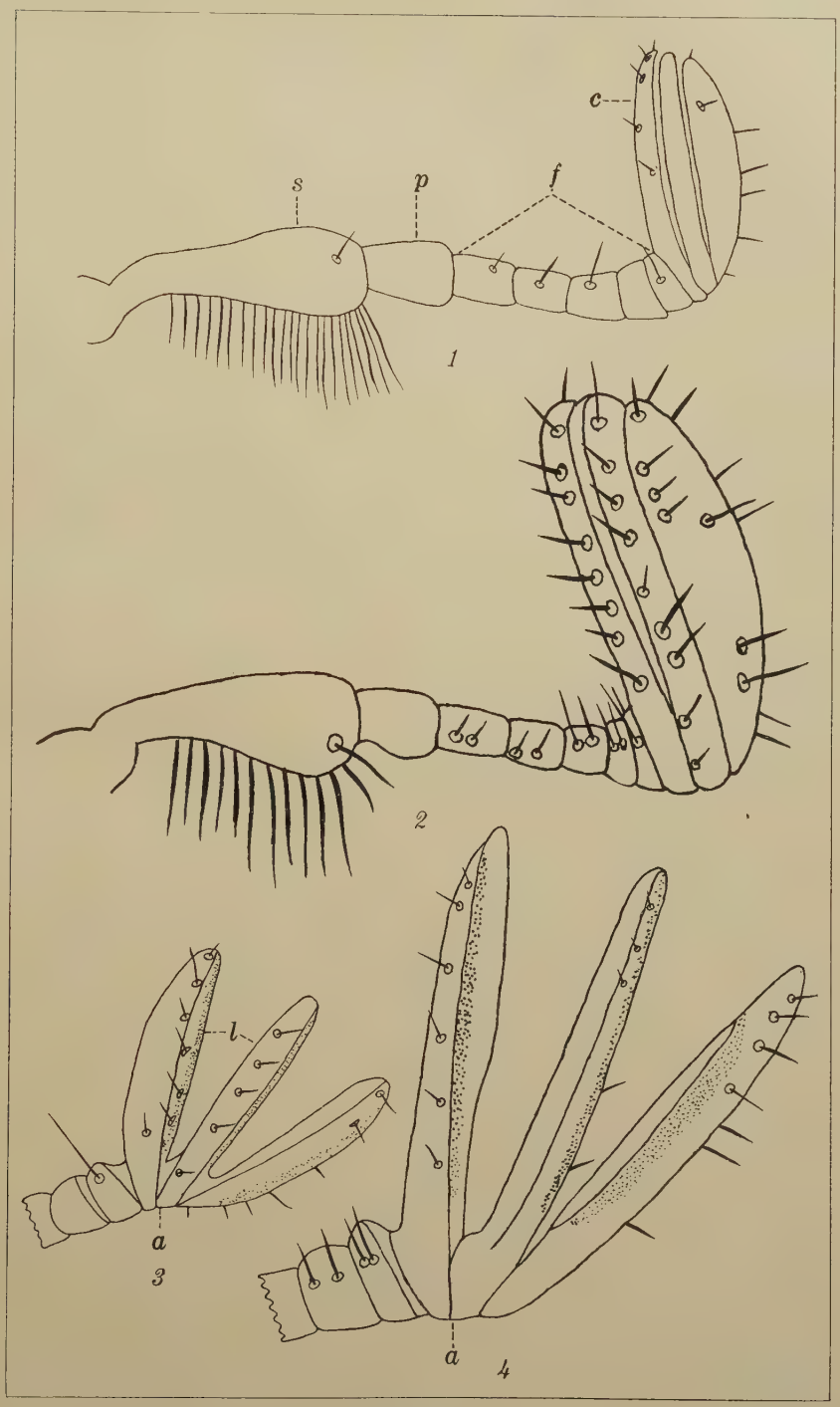

PLATE 1.

INDEX

[New names and new combinations are printed in **boldface.**]

A

Aberia gardneri, 516.
Abies magnifica, 4.
  sibirica, 4.
Acanthocephala Rudolphi, 538, 582, 584.
Acanthostigma bambusae v. Hoehn., 501.
Acer niveum, 515.
  sp., 515.
Acerbia maydis Rehm, 501.
Achrionota Pasc., 425, 435, 442.
  bilineata Pasc., 389, 425, 427, 442.
  spinifer Kln., 389, 425, 427, 442.
Acrostichum zollingeri Kze., 220.
Actiniptychus undulatus (Bail.) Ralfs, 97.
Actinodothis piperis Syd., 485.
Adelphomyia **apoana** Alex., 457, 458.
  carbonicolor Alex., 458.
  nebulosa (de Meij.), 459.
  paucisetosa Alex., 458, 459.
Aecidium, 518.
  alchorneae Sacc., 482.
  banosense Syd., 482.
  blumeae P. Henn., 482.
  clerodendri P. Henn., 482.
  elaeagni-latifoliae Petch., 482.
  flavidum Berk. & Br., 482.
  kaernbachii P. Henn., 482.
  lagunense Syd., 482.
  luzoniense P. Henn., 482.
  nummulare Berk., 482.
  paederiae Diet., 483.
  rhytismoideum Berk. & Br., 483.
  uvariae-rufae P. Henn., 483.
Aëdes, 43, 595, 604–606.
  ægypti Linn., 40, 595, 602, 607.
Aegiceras corniculatum, 527.
Afzelia bijuga, 498.
Agriorrhynchus Power, 418, 435, 441.
  ignarius Kln., 388, 418, 422, 441.
Aithaloderma clavatisporum Syd., 487.
Akis spinosa, 555.
Albizzia lebbek, 528.
  procera, 481.
Alchornea javanica, 528.
  rugosa, 482, 503, 528.
Aldona stella nigra Rac., 515.
ALEXANDER, CHARLES P., New or little-known Tipulidae from the Philippines (Diptera), X, 9; XI, 269; XII, 447.
Allaeodromus, 392.
Allium cepa, 531.
  sativum, 531.
Allophyllum dimorphum, 535.
Alocasia indica, 504.
Alsophila, 515.
Alstonia, 485.
  macrophylla, 489.
  scholaris, 485, 528.
Alternaria brassicae (Berk.) Sacc., 533.
Amorphocephalini, 390, 415, 431, 433, 434, 440.
Amorphophallus campanulatus, 480.
Amphicordus K. M. Heller, 422, 434, 441.
  improportionalis Heller, 389, 422, 441.
Amphisphaeria arengae Rehm, 503.
  schizostachyi Rehm, 503.
Amphisphaeriaceæ, 503.
Amphoromorpha entomophila Thaxter, 518.
Anagyrus sp., 222.
Ananas comosus, 489.
  sativa, 489.
  sativas, 489.
  sativus, 489.
Andropogon aciculatus, 484.
  citratus, 480.
  halepensis, 480, 500.
  halepensis var. propinquus, 500.
  sorghum, 480, 484, 488, 500, 507, 534.
Anepsiotes Kln., 424, 435, 442.
  luzonicus Calabr., 389, 424, 442.
  nitidicollis Calabr., 389, 424, 442.
Anisolabis annulipes, 555.
Anisopia farinalis, 555.
Anoa, 142.
  mindorensis, 142.
Anona muricata, 525.
Anopheles, 43, 639, 640, 645, 647.
  aconitus var. filipinæ Manalang, 40.
  albimanus, 657.
  bancrofti var. pseudobarbirostris (Ludlow), 646.
  barbirostris (van der Wulp), 646.
  culicifacies, 247, 641.
  edwardsi Yamada, 752.
  formosus, 751.
  fuliginosus (Giles) 646.
  funestus Giles, 47, 49, 56–58, 249, 253, 363, 365–367, 372–375, 644.
  gigas Giles, 751, 752.
  gigas Giles var. baileyi Edw., 752.

Anopheles—Continued.
gigas Giles var. formosus Ludlow, 751–753.
gigas Giles var. refutans Alcock, 752, 753.
gigas Giles var. simlensis James, 752.
hyrcanus var, sinensis (Wied.), 646.
kochi (Donitz), 645, 646.
lindesayi, 751, 754, 755.
lindesayi var. benguetensis King, 753, 755.
lindesayi var. cameronensis Edw., 754, 755.
lindesayi var. japonicus Yamada, 754.
lindesayi var. nilgiricus Christophers, 754.
lindesayi var. pleccau Koidzumi, 754.
ludlowi Theo., 40, 374, 642.
maculatus Theo., 40, 642, 753.
maculipennis Mg., 53, 363, 366.
minimus (Theo.), 644, 646.
philippinensis (Ludlow), 374, 646.
punctipennis, 364.
quadrimaculatus Say, 344, 364–367.
subpictus, 645.
tessellatus (Theo.), 645, 646.
vagus Donitz, 40, 374, 645, 646.
Antennæ, use of, as a means of determining the sexes in Leucopholis irrorata adults (Coleoptera, Scarabæidæ), 759.
Anthostoma eumorphum, 505.
Anthostomella arecae Rehm, 505.
arengae (Rac.) Rehm, 505.
atronitens Rehm, 505.
calami Rehm, 505.
calocarpa Syd., 505.
cocoina Syd., 505.
coryphae Rehm, 505.
coryphae Rehm f. minutissima Rehm, 505.
discophora, 506.
donacina Rehm f. arengae Rehm, 505.
eumorpha (Sacc. & Paoli) Rehm, 505.
grandispora Penz. & Sacc., 506.
lucens Sacc., 506.
micraspis (Berk.) Sacc. & Trav., 506.
mindorensis, 505.
mirabilis (B. & Br.) v. Hoehn., 506.
pandani (Rehm) Syd., 506.
uberiformis Rehm, 506.
Anthraxonis quartiniani, 483.
Antidesma bunius, 487.
Apherodothis arengae (Rac.) Shear, 501.
Aphodius, 578.
Aphysa desmodii Syd., 523.
Apiospora apiospora (Dur. & Mtg.) v. Hoehn., 496, 497.
camptospora Penz. & Sacc., 496.
carbonacea Rehm, 497.
luzonensis P. Henn., 496, 497.
montagnei, 496.
Apiphragma (Polyphragma) nigrotibiata, 463.
Apium graveolens, 530.
Apocemus Calabr., 423, 435, 441.
ignobilis Kln., 389, 423, 424, 441.
Apterorrhinus Senna, 429, 435, 442.
albatus Kln., 389, 429, 432, 442.
compressitarsis Senna 389, 429, 432, 442.
Arachis hypogaea, 529, 532.
Araiorrhynchus, 414.
Arcyria carnea G. Lister, 86, 92.
cinerea Pers., 85, 92.
denudata Wettstein, 85, 91.
Ardisia, 487.
Areca catechu, 505, 510, 511, 524, 527–529, 535.
Arenga, 503, 505, 517.
ambong, 536.
mindorensis, 502.
saccharifera, 490, 501, 510, 522, 523.
Arrhenodini, 390, 418, 422, 432–434, 441.
Artemisia sp., 88.
Arthraxonis sp., 483.
Artocarpus, 495, 519.
communis, 495, 520, 521, 531.
incisa, 520, 521, 531.
integra, 520, 521, 534.
integrifolia, 520, 521, 534.
Artotrogus, 518.
Asaphepterum Kln., 397, 433, 437.
formosanum Kln., 386, 397, 400, 437.
Ascaris, 564, 573.
Aschersonia, 493.
cinnabarina P. Henn., 526, 527.
confluens Henn., 493, 526.
javanica, 527.
lecanioides P. Henn., 527.
napoleonae, 527.
novo-guineensis, 527.
paraensis Henn., 527.
phthurioides, 526.
pisiformis, 527.
placenta B. & Br., 527.
samoensis Henn., 493, 527.
sclerotoides Henn., 493, 527.
Ascospora vanillae Rehm, 503.
Aspergillus delacrioixi Sacc. & Syd., 530.
flavus Link., 530.
periconioides Sacc., 530.
sp., 221.
Aspidium, 491.
Asplenium bulbiferum, 215.
bullatum, 215.
finlaysonianum Hook., 215.
finlaysonianum Wall., 214, 215.
flaccidum, 215.
hookerianum Wall., 214.
integerrimum Hook. & Grev., 214.
macrophyllum Sw., 214.
tripinnatifidum Copel., 215.
Asterina, 490.
breyniae Syd., 488.
breyniae Yates, 488.
capparidis Syd. & Bult., 488.
cassiae Syd., 488.
colliculosa Speg., 488.
decipiens Syd., 488.

Asterina—Continued.
dilleniae Syd., 488.
elmeri Syd., 488.
gmelinae Sacc., 488.
lawsoniae P. Henn. & Nym., 489.
laxiuscula Syd., 489.
lobata Syd., 489.
opposita Syd., 489.
pandani, 490.
pipturi Syd., 489.
pusillæ Syd., 489.
sponiae Rac., 489.
Asterinella calami Syd., 489.
luzonensis Syd., 489.
obesa Syd., 489.
stuhlmanni (Henn.) Theiss., 489.
Asterionella frauenfeldii Grun., 111.
glacialis Castr., 111.
japonica Cleve, 80, 111.
synedraeformis Grev., 111.
Asteroma phaseoli Brun., 520.
Astilbe philippinensis, 480.
Astrociptis mirabilis B. & Br., 506.
Astronia, 526.
Astrosphariella fusispora Syd., 506.
Ateuchus, 578.
Athyrium blumei, 214.
costulisorum, 214.
ophiodontum Copel., 214.
tenuifolium, 214.
umbrosum, 214.
Atopomorphus Kln., 398, 433, 437.
schultzei Kln., 386, 398, 400, 437.
Auerswaldia, 502, 505, 506.
decipiens, 505.
examinans (Mont. & Berk.) Sacc., 494.
gigantochloae Rehm, 494.
Aulacostroma palawanense Syd., 494.
Automobiles, decay of wood of, in the Tropics, 189.
Averrhoa carambola, 531.
Avian malaria studies, I, 305; II, 347; III, 651.

B

Bacillus coli, 611, 613, 616, 619, 736, 737, 739.
fluorescens, 735.
prodigiosus, 738.
proteus, 735.
subtilis, 613, 619.
Backet, *see* buakat.
Bacteriastrum, 95.
comosum Pavil. var. hispida (Castr.) Ikari, 109.
hyalinum Lauder, 108, 109.
minus Karst., 109.
varians Lauder, 108.
varians Lauder var. hispida (Castr.) Schröder, 109.
varians var. hyalina Lauder, 108.
wallichi Ralfs var. hispida Castr., 109.
Badhamia mandshurica Skv., 85, 86.
BAKER, C. F., Second supplement to the list of the lower fungi of the Philippine Islands, 479.
Bakerophoma sacchari Diedicke, 520.
Balansia claviceps Speg., 494.
Balladyna velutina (Berk. & Curt.) v. Hoehn., 485.
Bambusa, 493, 496, 497, 504, 506–508, 510, 512, 516, 522.
blumeana, 492, 499, 500–503, 506, 507, 510, 513, 515.
longinodis, 533.
vulgaris, 496, 503, 507, 509, 516.
sp., 496, 510, 513, 533.
Barleria cristata, 511.
Barya salaccensis, 493.
Baryrrhynchus Lac., 419, 435, 441.
schroederi Kln., 388, 419, 420, 422, 441.
Bauhinia, 513, 514.
comingiana, 491.
malabarica, 531.
Beetles, 555, 583.
dung, 578.
Belopherini, 390, 422, 424, 432, 433, 435, 441.
Beta vulgaris, 531.
Biddulphia aurita Brébisson var. orientalis Mereschkowsky, 109.
biddulphiana (Sm.) Boyer, 110.
longicornis Grev., 110.
pulchella Gray., 110.
sinensis Grev., 109.
Blaps mucronata, 583.
Blatta orientalis, 556, 578.
Blumea balsamifera, 482.
Botryodiplodia anceps Sacc. & Syd., 520.
curta Sacc., 520.
Botryosphaeria minuscula Sacc., 511.
Brassica chinensis, 88, 89, 531.
culta, 533.
pekinensis, 531.
sinensis, 531.
spp., 531.
Brenthini, 433.
Brentus bisulcatus F., 406.
Breynia cernua, 488.
Briardia maquilingiana Rehm, 517.
Bridelia glabrifolia, 481.
stipularis, 504.
Broomella zeae Rehm, 491.
Buakat, 257.
Bubalus indicus, 142.
mindorensis, 142.
Bulgariaceæ, 515.
Bulgariastrum caespitosum Syd., 515.

C

Cænorychodes Kln., 421, 435, 441.
serrirostris F., 389, 421, 422, 441.
splendens Kbm., 389, 421, 422, 441.
Calamus, 490, 503, 505, 507, 508, 511, 513.
sp., 489.
Calanthes, 523.

Callicarpa cana, 485.
sp., 485.
Calodromini, 390, 392, 431–433, 436.
Calodromus Guér., 392, 432, 436.
crinitus Kln., 386, 392, 400, 436.
mellyi Guér., 386, 392, 400, 436.
Calonectria copelandii P. Henn., 491.
hibiscola P. Henn., 492.
meliae A. Zimm., 491, 492.
sulcata Starb., 491.
Calopeziza mirabilis Syd., 515.
Camelia sativa, 518.
Campium subsimplex (Fée) Copel., 220.
Canarium villosum, 498.
sp., 489, 498, 515.
Canavalia, 528.
ensiformis, 517.
gladiata, 508, 517, 528, 531.
Capillariinæ Railliet, 564.
Capnodiaceæ, 487.
Capnodium footii Berk. & Desm., 487.
Capparis horrida, 488, 504, 508, 523, 524, 530, 535.
irosinensis, 488.
micracantha, 488, 533.
sepiaria, 515.
Capsicum annuum, 523, 526, 528, 536.
Carcara erosa, 482.
Carex sp., 88.
Carica papaya, 504, 507, 518, 519, 521, 522, 528, 530, 534.
Carissa arduina, 529.
Carthamus tinctorium, 533.
Caryota rumphiana var. philippinensis, 501.
sp., 504.
Cassava, 627.
Cassia occidentale, 532.
Catacauma apoense (Syd.) Theiss. & Syd., 497.
aspideum (Berk.) Theiss. & Syd. f. ficifulvae (Koord.) Theiss. & Syd., 497.
aspideum (Berk.) Theiss. & Syd. f. spinifera (Karst. & Har.) Theiss. & Syd., 497.
circinatum (Syd.) Theiss. & Syd., 497.
elmeri (Syd.) Theiss. & Syd., 497.
euryae (Rac.) Theiss. & Syd., 497.
garciae Theiss. & Syd., 497.
infectorium (Cke.) Theiss. & Syd., 498.
kaernbachii (P. Henn.) Theiss. & Syd., 498.
lagunense (Syd.) Theiss. & Syd., 498.
pterocarpi (Syd.) Theiss. & Syd., 498.
sanguineum (Rehm) Theiss. & Syd., 498.
valsiforme (Rehm) Theiss. & Syd., 498.
Cediocera Pasc., 425, 435, 442.
tristis Senna, 389, 425, 427, 442.
Cenangiaceæ, 515.
Cenangium blumeanum Rehm, 515.
Centeter, 129.
cinerea, 129.
Centotheca latifolia, 493, 494.
Ceratiomyxa fruticulosa, 86.
fruticulosa Macbr. var. flexuosa Lister, 86.
Ceratophyllus fasciatus, 556.
Cercospora acerosum Dickh. & Hein., 530.
apii Fres., 530.
armoraciæ Sacc., 531.
artocarpi Syd., 531.
bauhiniae Syd., 531.
beticola Sacc., 531.
brassicola Henn., 531.
canavaliae Syd., 531.
coffeicola Berk. & Cke., 531.
cruenta Sacc., 531.
duddiae Welles, 531.
gliricidiae Syd., 531.
henningsii Allesch., 531.
lactucae Stevenson, 531.
lactucae Welles, 531.
litseae-glutinosae Syd., 531.
lussoniense Sacc., 532.
mangiferae Koord., 532.
manihotis P. Henn., 532.
melongenae Welles, 532.
nicotianae Ell. & Evht., 532.
occidentalis Cke. var. cassiocarpa Sacc., 532.
overrhoi Welles, 531.
pachyderma Syd., 532.
pahudiae Syd., 532.
pantoleuca Syd., 532.
personata (B. & C.) Ell., 532.
puerariae Syd., 532.
sesami A. Zimm., 532.
stizolobii Syd., 532.
subsessilis Syd., 533.
tiglii Henn., 533.
ubi Rac., 533.
Cercosporina carthami Syd., 533.
Cerobates Schoenh., 402, 434, 437.
adustus Senna, 387, 402, 405, 438.
æqualis Kln., 387, 402, 405, 438.
angustipennis Senna, 387, 402, 403, 405, 438.
clinatus Kln., 387, 403, 405, 437.
costatus Kln., 387, 403, 405, 438.
formosanus von Schönf., 387, 403, 405, 438.
grouvellei Senna, 387, 403, 405, 438.
sexsulcatus Motsch., 387, 402–405, 438.
sumatranus Senna, 387, 404, 405, 438.
tristriatus F., 387, 402, 404, 405, 438.
Ceropegia sp., 482.
Cestoda Rudolphi, 546.
(s. str.) Monticelli, 546.
Cestodes, 538, 584.
Cestodiscus sol Grun., 97.
Ceuthocarpon depokense Penz. & Sacc., 506.
punctiforme Sacc., 506.
talaumae Rehm, 506.
Chaetoceras, 95.
affine Lauder, 106, 107.
angulatum Schütt, 107.

Chaetoceras—Continued.
atlanticum Cleve, 105.
atlanticum var. tumescens Grun., 105.
boreale Bail., 101.
boreale Cleve, 101.
boreale var. brightwellii Cleve, 101.
cellulosum Lauder, 100.
commutatum Cleve, 79.
compactum Schütt, 105.
compressum Lauder, 78, 104.
compressum var. gracilis Hustedt, 78.
constrictum Gran., 79.
contortum Schütt, 104.
criophilum Castr. forma volans (Schütt) Gran, 78, 106.
dadayi Pavil., 105.
decipiens Cleve, 79, 104.
didymum, 103.
didymum Ehrenb. var. anglica Gran, 78, 103.
didymum Ehrenb. var. genuina Gran, 103.
didymum var. longicruris Cleve, 103.
dispar Castr., 105.
distans Cleve, 79.
distans Ostenf., 79.
distans var. laciniosæ Schütt, 80.
distichum Schütt, 106.
furca Cleve, 107.
furca Cleve var. macroceras Schröder, 107.
gracile Schütt, 79.
grunowii Schütt, 104.
ikari Skv., 102.
javanicum Cleve, 100.
laciniosum Schütt, 79.
lauderi Ralfs var., 101.
lorenzianum Grun., 100.
medium Schütt, 104.
messanense Castr., 107.
misumense Gran & Yendo, 101.
okamurai Ikari, 106.
ostenfeldii Cleve, 79.
pelagicum Cleve, 79.
peruvianum Brightw., 106.
procerum Schütt, 107.
protuberans Lauder, 103.
radians Schütt, 104.
ralfsii Cleve, 106.
reichelti Hustedt, 102.
saltans Cleve, 106.
schüttii Cleve, 106.
septentrionale Oestrup, 79.
siamense Ostenf., 101.
skeleton Schröder, 105.
sociale Lauder, 78, 102.
spirillum Castr., 108.
tortissimum Gran., 105.
varians (Lauder) V. Heurck, 108.
sp., 80, 107.
Chaetosphaeria eximia Sacc., 501.
Champereia cumingiana, 488.
manillana, 488.
sp., 488.
Chrysophyllum oliviformis, 487.
Chytridiales, 517.
Cintractia axicola (Berk.) Cornu, 484.
Cissus sp., 486.
Citrus, 513.
aurantifolia, 510.
decumana, 510.
maxima, 510, 513, 522, 524, 527, 528.
nobilis, 503, 509–512, 516, 521, 524, 526.
sp., 485, 521, 527.
spp., 519, 523, 524.
Cladosporium herbarum L., 533.
lineolatum Sacc., 533.
Claoxylum sp., 483.
Clasterosporium maydicum Sacc., 533.
Clavicipteæ, 493.
Clerodendron fragrans, 482.
inermis, 480.
minahassae, 480.
sp., 485.
Climacodium biconcavum Cleve, 98.
Clitoria ternatea, 532.
Clypeosphaeria bakeriana Rehm, 506.
Clypeosphaeriaceæ, 505.
Coccomyces, 495.
dubius Rehm, 517.
quadratus (Schw. & Kze.) Karst. var. philippinus Rehm, 517.
Cockroaches, 556, 575, 578, 583.
Cocos nucifera, 487, 495, 501, 502, 505, 510, 519, 521, 524, 529, 535.
Coexistent infection with yaws and syphilis, 177.
Coffea arabica, 479, 520.
excelsa, 491.
spp., 479, 520, 531.
Coix lachryma-jobi, 498, 509.
COLE, HOWARD IRVING, Causes of irritation upon injection of iodized ethyl esters of Hydnocarpus-group oils, 377.
Coleoptera, 759.
Coleosporiaceæ, 481.
Coleosporium exaci Syd., 481.
knoxiae Syd., 481
merrillii P. Henn., 481.
Colletotrichum arecae Syd., 527.
arecae Syd. forma setis perpaucis praedita, 528.
euchroum Syd., 528.
falcatum Went., 528.
gloeosporioides Penz., 528.
lussoniense Sacc., 528.
nigrum Ell. & Hals., 528.
payayae (Henn.) Syd., 528.
Colocasia antiquorum, 519.
esculentum, 519.
Commelina, 483.
Composition of Philippine kapok-seed oil, 131; of Philippine peanut oil, 199.

Coniosporium bambusae (Thuem. & Bolle) Sacc., 533.
extremorum Syd., 533.
oryzinum Sacc., 533.
unilaterale Sacc., & Peyr., 533.
vinosum (B. & C.) Sacc., 533.
Coniothyrium coffeae Henn., 520.
Conosia irrorata (Wied.), 27.
Construction, bored-hole latrine equipment and, 681.
Control of the common pink mealybug Trionymus sacchari (Cockerell) of sugar cane on Negros, 221.
COPELAND, EDWIN BINGHAM, New or interesting oriental ferns, 209.
Cordus Schoenh., 415, 434, 440.
peguanus Senna, 388, 415, 440.
Corethron pelagicum Brun., 97.
Coriaria, 257, 259, 260.
intermedia Mats., 257–259, 263.
japonica A. Gray, 258, 259.
myrtifolia Linn., 258, 261.
ruscifolia Linn., 258.
Coriariaceæ, 257.
Cormopus Kolbe, 392, 396.
Corynelia clavata (L.) Sacc., 503.
Coryneliaceæ, 503.
Corypha elata, 505, 525.
Coscinodiscus, 95.
concinnus W. Sm., 96.
excentricus Ehrenb., 96.
fragilissimus Grun., 96.
hyalinus Grun., 98.
mirificus, 96.
papuanus, 96.
radiatus Ehrenb., 96.
sol Wall., 97.
Croton tiglium, 525, 533.
CRUZ, AURELIO O., and AUGUSTUS P. WEST, Composition of Philippine kapok-seed oil, 131; Composition of Philippine peanut oil, 199.
Cryptocarya sp., 491.
Cucumis sativus, 523.
Cucurbitariaceæ, 503.
Cudrania javanica, 536.
Cuestis diffusa, 488.
Culex, 43.
fatigans, 656.
pipiens, 657, 659, 660, 663.
quinquefasciatus Say, 40, 657, 659, 660, 667.
sp., 40.
(Culex) pipiens Linn., 656.
(Culex) quinquefasciatus Say, 656.
Cyanopsis psoraleoides, 522.
Cyanotis axillaris, 483.
Cyathea **bontocensis** Copel., 209.
callosa, 211.
calocoma (Christ.) Copel., 210.
caudata, 211, 212, 515.
clementis, 210.
contaminans (Wall.) Copel., 210.
Cyathea—Continued.
dupaxensis Copel., 211.
edañoi Copel., 211.
halconensis, 212.
heteroloba, 210.
mearnsii, 212.
melanophlebia Copel., 212.
merillii Copel., 212.
pustulosa (Christ.) Copel., 212.
squamicosta Copel., 212.
Cyathus, 517.
Cyclophyllidea Braun, 546.
Cyclostemon sp., 526.
Cynodons dactylis, 499.
Cynomys ludovicianus, 564.
Cyperus compressus, 480.
Cyphagogus Parry, 392, 395–397, 433, 436.
buccatus Kln., 386, 392–394, 400, 436.
eichhorni Kbm., 386, 393, 394, 400, 436.
gladiator Kln., 386, 393, 400, 436.
humilis Kln., 386, 393, 400.
longulus Senna, 386, 393, 400, 436.
modiglianii Senna, 386, 394, 396, 400, 436.
planifrons Kln., 386, 394, 400, 436.
silvanus Senna, 386, 394, 400, 436.
simulator Senna, 386, 394, 400, 436.
tabacicola Senna, 386, 395, 400, 436.
westwoodi Parry, 386, 395, 400, 436.
whitei Westw., 386, 395, 400, 436.
Cyrilla, 513.
Cysticercus fasciolaris Rudolphi, 538, 546.
sp., 546.
Cytospora aberrans Sacc., 521.
palmicola B. & Cke., 521.

D

Daemonorops, 490, 502.
Dalbergia sp., 499.
Daldinia concentrica (Bolt.) Ces. & de Not., 513.
concentrica var. microspora (Starb.) Theiss., 513.
escholzii Ehr., 513.
Darwiniella, 494.
Datura alba, 521, 526.
Davainea formosana Akashi, 585.
madagascariensis Garrison, 549, 585.
madagascariensis (Davaine) Garrison, 548.
Davaineidæ Fuhrmann, 548.
Davaineinæ, 548.
Decay of wood in automobiles in the Tropics, 189.
Deeringia baccata, 481.
Dematiaceæ, 530.
Dendrodochium lussonense Sacc., 535.
Dengue, notes on, 593.
virus, resistance of, 601.
Derris elliptica, 500.
philippinensis, 515.
sp., 500.

Desmodium pulchellum, 486.
sinuosum, 523.
triflorum, 487.
Detonula schroederi Gran, 99.
Diaporthe citrincola Rehm, 510.
recondita Sacc., 510.
Diatoms, pelagic, of Korean strait of the Sea of Japan, 95.
plankton, from Vladivostok Bay, 77.
Diatrypaceæ, 511.
Diatrypella barleriae Syd., 511.
psidii Syd., 511.
Dichotomella areolata Sacc., 534.
Dictydium cancellatum Macb., 89.
Dictyothyriella muscosa Syd., 491.
Dictyotopterus Kln., 399, 433, 437.
philippinensis Kln., 386, 399, 400, 437.
pulcherrimus Kln., 386, 399, 400, 437.
Diderma globosum Pers., 88.
rugosum, 88.
rugosum Macb. var. asiatica Skv., 85, 88.
spumarioides Fries, 85, 88.
Didymella caricae Tassi, 507.
eutypoides Rehm, 507.
lussoniensis Sacc., 507.
orchnodes Rehm, 507.
seriata Rehm, 507.
Didymium dubium, 86.
Didymosphaeria anisomera Sacc., 507.
caespitulosa Sacc., 507, 508.
inconspicua Rehm, 507.
striatula Penz. & Sacc., 507, 508.
Didymotrichia, 502.
Die Brenthiden der Philippinen-Inseln, 383.
Diedickea singularis Syd., 527.
Digenea v. Beneden, 539.
Dillenia philippinensis, 488.
Dimerina graffii Syd., 485.
Dimerium tayabense Yates, 485.
Dimerocalyx longipes, 516.
Dinochloa, 490, 504, 508.
sp., 500.
Diochus conicicallis Mots., 518.
Dioscorea, 483.
aculeata, 525.
alata, 483, 532.
esculenta, 483, 495, 499, 522–525, 529, 532, 533.
sp., 499.
spp., 524, 532, 533.
Diospyros discolor, 483.
sp., 536.
Diphasium, 209.
Diplodia artocarpi Sacc., 521.
artocarpina Sacc., 521.
caricae Sacc., 521.
circinans B. & Br., 521.
cococarpa Sacc., 521.
cococarpa var. malaccensis Tassi, 521.
crebra Sacc., 520.
daturae Sacc., 521.
durionis Sacc. & Syd., 521.
manihoti Sacc., 521.
Diplodia—Continued.
mori West., 522.
phaseolina Sacc., 522.
ricinicola Sacc., 522.
synedrellae Sacc., 522.
Diplodina degenerans Diedicke, 522.
Diptera, 129.
Philippine, 9.
Dipterocarpus grandiflorus Blco., 195.
spp., 195.
Discodothis lobata Syd., 515.
Distomata Zeder, 539.
Ditylium brightwellii (West) Grun., 77, 100.
sol V. Heurck, 100.
Diurus Pasc., 426, 435, 442.
furcillatus Gyll., 389, 426, 427, 442.
philippinicus Senna, 389, 426, 427, 442.
samarensis Kln., 389, 426, 427, 442.
shelfordi Senna, 389, 426, 427, 442.
Dolichopeza Curt., 269–271.
isolata Alex., 269.
(Mitopeza) longicornis (Brun.), 272.
(Mitopeza) nigromaculata (Edw.), 272.
(Mitopeza) nitidirostris (Edw.), 272.
(Mitopeza) rizalensis Alex., 271, 272.
(Nesopeza) angustaxillaris Alex., 272, 273.
(Nesopeza) melanosterna Alex., 272.
Dolichos gibbosus, 518.
lablab, 507, 518, 526.
uniflorus, 507, 526.
Donax cannaeformis, 493, 505, 509.
Dothidea, 493, 494.
Dothideales, 494.
Dothidella, 500.
gigantochloae (Rehm) Theiss. & Syd., 494.
Dothidiaceæ, 494.
Dothiorella crastophila Sacc., 522.
Dracontomelum cumingianum, 506.
Dryopteris clemensiae Copel., 213.
otaria, 213.
parasitica (L.) O. K., 213.
Dunbaria ferrignes, 518.
sp., 523.
Dung beetles, 578.
Durio zibethinus, 521, 525.
Dysoxylum, 524.

E

Earwig, 555.
Echinorhynchata Faust, 582.
Echinorhynchus cestodiformis Linstow, 582.
moniliformis Bremser, 582.
Echinostoma gotoi Ando, 544.
ilocanum, 539.
Echinostomatidæ Looss, 539.
Echinostomatinæ Looss, 539.
Echinostomatoidea Faust, 539.
Enterobius vermicularis, 570.
Ectocemus Pasc., 424, 441.
badeni Kbm., 389, 424, 441.
Elæagnus philippinensis, 482.

Ellisiodothis pandani Syd., 495.
rehmiana Theiss. & Syd., 495.
Elmerococcum orbicula Syd., 494.
Elsinoe canavaliae Rac., 517.
Elsinoeæ, 517.
Endoxyla mangiferae Henn., 510.
Entyloma oryzae Syd., 484.
Ephydatia, 73.
fortis Weltner, 61, 71.
Epichloe warburgianæ P. Magn., 493.
Epigogus Kln., 396, 433, 436.
flexibilis Kln., 386, 396, 400, 436.
Epiphragma, 448.
bakeri Alex., 23.
ochrinota, 24.
(Polyphragma) **angusticrenula** Alex., 468, 469.
(Polyphragma) **apoensis** Alex., 463, 466.
(Polyphragma) bakeri Alex., 23.
(Polyphragma) caninotæ Alex., 466, 468.
(Polyphragma) cinereinota Alex., 467.
(Polyphragma) crenulata Alex., 467–469.
(Polyphragma) fulvinota Alex., 461, 462, 464.
(Polyphragma) **fuscofasciata** Alex., 459, 460.
(Polyphragmæ) fuscosternata Alex., 464, 466.
(Polyphragma) **griseicapilla** Alex., 467, 468.
(Polyphragma) **hastata** Alex., 464, 466.
(Polyphragma) **latitergata** Alex., 460.
(Polyphragma) **nigrotibiata** Alex., 462.
(Polyphragma) ochrinota Alex., 23, 460, 462, 464.
(Polyphragma) **parviloba** Alex., 23.
Eriocera, 26.
Erioptera Meig., 286, 289.
argentifrons Edw., 287.
fusca de Meij., 287.
melanotænia Alex., 287.
nigribasis Edw., 287.
parallela Brun., 287.
punctipennis Brun., 287.
subfusca Edw., 287.
(Empeda) gracilis (de Meij.), 289.
(Empeda) **lunensis** Alex., 288, 289.
(Empeda) rubripes Alex., 27.
(Teleneuræ) fusca de Meij., 287.
(Teleneura) **melanotænia** Alex., 287.
Eriopterini, 28, 269, 284.
Erysiphaceæ, 484.
Erythrina indica, 483, 534.
ESGUERRA, P. D., *see* SANTOS, WEST, and ESGUERRA.
Esters, iodized ethyl, causes of irritation upon injection of, of hydnocarpus-group oils, 377.
Eterozemus Senna, 398, 433, 437.
lætus Senna, 386, 398, 400, 437.
pubens Senna, 386, 399, 400, 437.
Ethmodiscus convexus Castr., 96.
Eucampia, 95.
biconcava (Cleve) Ostenf., 97.
hemiauloides Ostenf., 97.
zodiacus Ehrenb., 97.
Euchlaena luxurians, 525.
Eugenia, 490, 508.
bataanensis, 506, 509.
calubcub, 490.
jambolana, 488.
Eunematoda Ward., 560.
Euparyphium Dietz, 539, 545.
guerreroi Tubangui, 538, 542, 584.
ilocanum (Garrison) Tubangui, 538, 539, 544, 584.
murinum Tubangui, 538, 543, 584.
Eupeithes Senna, 418, 435, 441.
dominator Kln., 388, 418, 422, 441.
Euphorbia neriifolia, 528.
Eupsalis Lac., 420, 421, 434, 441.
kleinei Heller, 389, 420, 422, 441.
Eutrachelini, 433.
Eutrixopsis javana Tns., 129.
Eutypa bambusina Penz. & Sacc., 510.
heteracantha Sacc., 510.
ludibunda Sacc., 510.
Eutypella citricola Speg., 510.
cocos Ferd. & Winge, 510.
leucaenae Rehm, 511.
lineolata Rehm, 511.
malloti Rehm, 511.
rehmiana (Henn. & Nym.) v. Höhn., 511.
Evonymus japonicus, 491.
Exacum chironioides, 481.
Exarmidium blumeanum (Rehm) Theiss. & Syd., 498.
Exosporium durum Sacc., 535.
pulchellum Sacc., 535.

F

Fascioletta ilocanæ Garrison, 539.
Ferns, oriental, new or interesting, 209.
Fever, rat-bite, in the Philippines, 159.
Ficus, 507, 534.
banahaensis, 501.
carica Linn., 482, 483.
caudatifolia, 534.
garcia, 497.
hauili, 498.
heterophylla, 498, 501.
minahassæ, 497, 517.
nervosa, 497.
odorata, 497.
odoratus, 497.
pseudopalma, 492.
ulmifolia, 489.
validicaudata, 497.
sp., 497, 498, 523.
Fimbristylis diphylla, 484.
Fleas, rat, 556.
FLEMING, WM. D., *see* HOLT, FLEMING, and KINTNER.

Fly Eutrixopsis javana Townsend (Diptera, Tachinidæ), a parasite of the beetle Leucopholis irrorata in Occidental Negros, Philippine Islands, 129.
Freycinetia, 512.
Fuligo muscorum Alb. & Schwein, 85, 87.
septica Gmel., 85, 87.
septica Gmel. var. rufa R. E. Fries, 87.
Fumago vagans Pers., 488.
Fungi imperfecti, 520.
Fungi, second supplement to the list of the lower, of the Philippine Islands, 479.
Fusarium cubense Efs., 535.
theobromae App. & Strunk., 536.

G

Ganguleterakis gangula Lane, 571.
GEE, N. GIST, Fresh-water sponges of the Philippine Islands, 61.
Gibbera philippinensis Rehm, 503.
Gibberella saubinetii (Mont.) Sacc., 492.
Gigantochloa scribneriana, 494, 516.
Gigantorhynchus moniliformis (Bremser) Railliet, 582.
Gilletiella, 491.
latemaculans Rehm, 490.
Gliricidia maculata, 510, 523.
sepium, 492, 526, 531.
Gloeosporium affine Sacc., 528.
alchorneae Syd., 528.
alstoniae Sacc., 528.
canavaliae Syd., 528.
catechu Syd., 528.
lebbek Syd., 528.
macrophomoides Sacc., 528, 529.
musarum Cke. & Mass., 529.
palmarum Oud., 529.
vanillae Cke., 529.
Glomerella cingulata (Stonem.) S. & v. S., 509.
Glycine hispida, 481, 484.
javanica, 518.
max, 481, 484.
sojae, 481, 484.
Gmelia philippinensis, 485.
Gmelina, 488.
Gnomoniaceæ, 509.
Gongylonema Molin, 575.
neoplasticum (Fibiger & Ditlevsen) Ransom & Hall, 538, 575, 576, 584.
orientale Yokogawa, 575.
pulchrum, 576.
Gongyloneminæ Hall, 575.
Goniothalamus, 507.
Gonomyia diffusa, 31.
flavomarginata (Brun.), 32, 33.
incompleta Brun., 29.
(Leiponeura) insulensis Alex., 29.
(Lipophleps) **alboannulata** Alex., 31, 32.
(Lipophleps) bicolorata Alex., 27.
Gonomyia—Continued.
(Lipophleps) diffusa (de Meij.), 32.
(Lipophleps) flavocostalis Alex., 33.
(Lipophleps) incompleta Brun., 29.
(Lipophleps) liberiensis Alex., 31.
(Lipophleps) **luteimarginata** Alex., 32.
(Lipophleps) **maquilingia** Alex., 28, 29.
(Lipophleps) noctabunda Alex., 31.
(Lipophleps) nubeculosa de Meij., 31.
(Lipophleps) pallidisignata Alex., 30.
(Lipophleps) robinsoni Edw., 34.
(Lipophleps) **secreta** Alex., 33, 34.
(Lipophleps) sobrina Alex., 31.
(Progonomyia) brunnescens Edw., 286.
(Progonomyia) tenebrosa Edw., 286.
(Progonomyia) **terebrella** Alex., 285, 286.
(Ptilostena) **punctipennis** Edw., 35.
Gossypium sp., 483.
spp., 481.
Grammatophora japonica Grun., 111.
marina (Lyngb.) Kütz., 112.
Grammitis bulbotricha, 219.
congener, 219.
fasciata, 220.
limapes Copel., 218, 219.
longa Fée, 220.
multifolia Copel., 219.
multifolia Copel., var. β lasiosora Blm., 220.
nana Fée, 220.
pubinervia, 219, 220.
pusilla, 219.
setosa, 220.
stenocrypta Copel., 220.
Graphiola arengae Rac., 536.
cylindrospora Syd., 536.
Grewia, 515.
stylocarpa, 506.
Guignardia arengae Rehm, 504.
bambusina Rehm, 504.
creberrima Syd., 504.
dinochloae Rehm, 504.
manihoti Sacc. var. diminuta Sacc., 504.
Guinardia baltica Schütt, 114.
flaccida (Castr.) Per., 114.
Guioa perrottetii, 486.
Gymnema tingentis, 482.
Gymnospora spinosa, 486.

H

HADDEN, F. C., and A. W. LOPEZ, Efforts toward biological control of the common pink mealybug Trionymus sacchari (Cockerell) of sugar cane on Negros, 221.
Hadronema orbiculare Syd., 534.
Haemoproteus, 656.
Hamaspora acutissima Syd., 480.
Haplospora manilensis Sacc., 522.
Hare, European, 564.
Harknessia, 495.

Heligmosominae Travassos, 567.
Heligmosomum muris Yokogawa, 567.
Heliotropus indicus, 530.
Helius (Eurhamphidia abnormalis (Brun.), 283, 284.
(Eurhamphidia) diacanthus (Alex.), 283, 284.
(Eurhamphidia) fuscofemoratus Alex., 282, 288.
(Eurhamphidia) indivisus Alex., 283.
(Eurhamphidia) nigrofemoratus (Alex.), 283.
(Helius) apoensis Alex., 455.
(Helius) arcuarius Alex., 455.
(Helius) procerus Alex., 454, 455.
(Helius) trianguliferus Alex., 456.
(Rhampholimnobia) reticularis (Alex.), 23.
Helminthosporium caryopsidum Sacc., 534.
curvulum Sacc., 534.
ficinum Sacc., 534.
ficinum Yates, 534.
inconspicuum C. & Ell., 534.
inversum Sacc., 534.
oryzae Breda de Haan, 534.
papayae Syd., 534.
ravenelii Berk. & Curt., 534.
Helotiaceæ, 516.
Hemileia canthii Berk. & Br., 479.
vastatrix Berk. & Br., 479.
Hemisphaeriaceæ, 491.
Hemisphaeriales, 488.
Hemitrichia clavata Rost., 85, 91.
serpula Rost., 91.
vesparium Macbr., 91.
Henarrhenodes K. M. Heller, 423, 435, 441.
macgregori Heller, 389, 423, 441.
Henseniella baltica Schütt, 114.
Hepaticola Hall, 564.
hepatica (Bancroft) Hall, 538, 564, 566, 584.
Herpotrichia, 502.
Heterakidæ Railliet & Henry, 571.
Heterakinæ Railliet & Henry, 571.
Heterakis Dujardin, 571.
gallinae, 572.
spumosa Schn., 538, 571, 584.
Heteroblysmia Kln., 423, 535, 441.
accurata Kln., 389, 423, 424, 441.
electa Kln., 389, 423, 424, 441.
formidolosa Kln., 389, 423, 424, 441.
Heterodothis leptotheca Syd., 494.
Heteroplites Lac., 426, 442.
Pasc., 435.
erythroderes Boh., 389, 426, 427, 442.
Hevea, 519.
brasiliensis, 491, 494, 516, 522.
Hewittia sublobata, 486.
Hexatomini, 23, 457.
Heynea sumatrana, 489.
Hibiscus, double, somatic segregation in, 627.
esculentus, 492.
Hibiscus—Continued.
rosa-sinensis Linn., 628, 635.
sabdariffa, 524.
syriacus Linn., 633.
Higonius Lewis, 413, 434, 440.
cilo Lewis, 388, 413, 417, 440.
crux, 413.
Histamine test as an aid in the diagnosis of early leprosy, 123.
Holcus sorghum, 480, 484, 488, 500, 507, 534.
HOLT, R. L., and J. H. KINTNER, Notes on Dengue, 593.
HOLT, R. L., WM. D. FLEMING, and J. H. KINTNER, Resistance of dengue virus, 601.
Homophylus Kln., 406, 434, 438.
mindanensis Kln., 387, 406, 416, 438.
Hoplopisthius Senna, 414, 400, 434.
trichimerus Senna, 388, 414, 417, 440.
Hormocerus Schoenh., 428, 435, 442.
reticulatus F., 389, 428, 432, 442.
scrobicollis, 428.
Hormorhynchus moniliformis (Bremser) Ward, 582.
Hoya, 528.
luzonica, 508.
Humaria caballina Rehm, 516.
HUMPHREY, C. J., Decay of wood in automobiles in the Tropics, 189.
Hymenolepididæ Railliet & Henry, 553.
Hymenolepidinæ Ransom, 553.
Hymenolepis Weinland, 553.
diminuta (Rudolphi) Blanch., 538, 553, 584.
flavopunctata Weinland, 553.
fraterna Stiles, 556.
longior Baylis, 556.
nana (Sieb.) Blanch., 554, 556, 584.
vide Joyeux, 556.
vide Woodland, 556.
Hymenopsis cudraniae Mass., 536.
Hymenula copelandi Sacc., 536.
Hyphales, 530.
Hypocrea, 493.
Hypocreaceæ, 491.
Hypocreales, 491.
Hypocrella cretacea, 493.
discoidea (Berk. & Br.) Sacc., 493, 527.
globosa, 493.
grewiae, 493.
mollii Koord., 493, 526.
pernettyae, 493.
reciborskii A. Zimm., 493.
reineckiana P. Henn., 493, 527.
salaccensis (Rac.) Petch., 493.
schizostachyii P. Henn., 493.
warneckiana, 493.
zimmermanniana, 493.
zingiberis, 493.
Hypodermataceæ, 514.

Hypomiolispa Kln., 411, 412, 434, 439.
exarata Desbr., 388, 411, 416 439.
helleri Kln., 388, 411, 416, 440.
nupta Senna, 388, 411, 412, 417, 440.
ocularis Kln., 388, 412, 418, 440.
sponsa Kln., 388, 412, 417, 440.
tomentosa Kln., 388, 412, 417, 440.
trachelizoides Senna, 388, 412, 417, 440.
Hypoxylon annulatum (Schw.) Mont., 512.
atropurpureum Fr., 512.
culmorum Cke., 512, 513.
effusum Nitsch., 512.
freycinetiae Rehm, 512.
granulosum Bull., 512.
haematostroma Mont., 512.
marginatum (Schw.) Berk., 512.
marginatum (Schw.) Berk. var. mammiforme Rehm, 512.
rubigineo-areolatum Rehm var. microsporum Theiss., 512.
subeffusum Speg., 512.
Hyptis suaveolens, 486.
Hysteriaceæ, 515.
Hysteriales, 514.
Hysterium, 514.
anceps Sacc., 515.
Hysterostomella, 495, 515.
latracerae (Rud.) v. Hoehn., 495.
spurcaria (Berk. & Br.) v. Hoehn., 495.
tetracerae (Rud.) v. Hoehn., 495.

I

Idiophlebia Grunberg, 294.
Illosporium tabacinum Sacc., 536.
Imperata cylindrica, 492, 504, 535.
Inocyclus psychotriae Syd., 495.
Interpretation of the laws of Brown and Pearce that govern the course of treponematoses, 169.
Ipomoea batatas, 522.
pes-caprae, 482.
Isachne miliacea, 484.
Ischaemum aristatum, 484.
Isothea, 499.
Itea macrophylla, 486.
Ithystenini, 390, 425, 427, 432, 433, 435, 442.
Ixora sp., 487.

J

Jonthocerus Lac., 399, 400, 434, 437.
asiaticus Kln., 387, 399, 401, 405, 437.
bicolor Heller, 387, 400, 405, 437.
laticostatis Kln., 387, 401, 405, 437.
modiglianii Senna, 387, 401, 405, 437.
Justicia gendarussa, 480.

K

Kahn test in clinical syphilis, 225.
Kapok-seed oil, composition of, 131.
KING, W. V., The Philippine varieties of Anopheles gigas and Anopheles lindesayi, 751.
KINTNER, J. H., *see* HOLT and KINTNER; *see also* HOLT, FLEMING, and KINTNER.
KLEINE, R., Die Brenthiden der Philippinen-Inseln, 383.
Knoxia corymbosa, 481.
Korean strait of the Sea of Japan, pelagic diatoms of, 95.
Kotlania madagascariensis (Davaine), 585.
Kretzmaria ghomphoidea Penz. & Sacc., 513.
Kuehneola desmium (Berk. & Br.) Arth., 481.
fici (Cast.) Butl., 482.
fici (Cast.) Butl. f. moricola F. Henn., 482.

L

Labia sp., 518.
Lachnea livida (Schum.) Gill., 516.
lurida P. Henn. & E. Nym., 516.
Lactuca sativa, 531.
Lagenaria leucantha, 509.
Lagerheima dermatoidea Rehm, 515.
Lagerstroemia indica, 515, 517.
speciosa, 515, 517.
Laosa, 448.
Lasiodiplodia theobromae (Pat.) Griff. & Maubl., 522.
Lasiosphaeria mollis Rehm, 501.
Lasiothyrium cycloschizon Syd., 527.
Latrine equipment and construction, 681.
Lauderia, 95.
annulata Cleve, 99.
borealis Gran, 99.
compressa Per., 99.
delicatula Per., 99.
Lauderiopsis costata Ostenf., 99.
Laws of Brown and Pearce, an interpretation of the, that govern the course of treponematoses, 169.
Lawsonia inermis, 489.
Leaf and seed structure of a Philippine Coriaria, 257.
Lembosia, 496.
congregata Syd., 490.
crustacea (Cke.) Theiss., 490.
eugeniae Rehm, 490.
javanica (Pat.) Rac., 490.
pandani (Rostr.) Theiss., 490.
pothoidei Rehm, 490.
Lenzites striata, 193.
LEON, WALFRIDO DE, *see* OLIVER, LEON, and RODA.
Lepidiota pruinosa, 761.
Lepidium sativum, 518.
Lepidoderma mandshurica Skv., 85, 88.
Lepisanthes schizolepis, 491.
Lepistemon flavescens, 482.
Leprosy, histamine test as an aid in the diagnosis of early, 123.

Leptamorphocephalus Kln., 415, 434, 440.
fœderatus Kln., 388, 415, 440.
Leptochilus lanceolatus, 220.
Leptocylindrus **curvatus** Skv., 100.
danicus Cleve, 77.
Leptosphaeria orthogramma (B. & C.) Sacc., 508.
Leptostromataceæ, 527.
Leptothyrium circumscissum Syd., 527.
Lepus europus, 564.
Leucaena glauca, 511.
Leucopholis irrorata Chevr., 129, 759.
Libnotes, 448, 449, 451.
Licea biforis Morgan, 86, 89.
brassica Skv., 85, 89.
flexuosa Pers., 89.
mandshurica Skv., 85, 89.
Limacinia biseptata Sacc., 488.
Limacinula malloti Rehm, 488.
Limnophila granulata, 25.
(Ephelia) granulata Edw., 25.
(Ephelia) **igorota** Alex., 24, 25.
Limonia, 449, 451.
argentifera de Meij., 19, 20.
cynotis, 14, 15.
manca Alex., 19, 20.
morionella Schiner, 16.
multinodulosa, 12.
nigronitida Alex., 20.
nigronotata Brun., 20.
pleuropalloris Alex., 20.
rostrifera, 16.
sorbillans (Wied.), 20.
unicinctipes, 21.
(Alexandriaria) **sollicita** Alex., 21, 22.
(Dicranomyia) fullowayi (Alex.), 282.
(Dicranomyia) mesosternata (Alex.), 281.
(Dicranomyia) **mesosternatoides** (Alex.), 281.
(Dicranomyia) **neopunctulata** Alex., 282.
(Dicranomyia) **orthia** Alex., 281.
(Dicranomyia) punctalata (de Meij.), 282.
(Dicranomyia) sordida (Brun.), 22.
(Dicranomyia) subpunctulata Alex., 282.
(Geranomyia) argentifera (de Meij.), 27.
(Geranomyia) **longifimbriata** Alex., 18, 19.
(Geranomyia) **paramanca** Alex., 19, 20.
(Geranomyia) **phœnosoma** Alex., 17, 18.
(Goniodineura) nigriceps, (van der Wulp), 27.
(Laosa) gloriosa (Edw.), 448.
(Laosa) **manobo** Alex., 447–449.
(Libnotes) amatrix Alex., 280.
(Libnotes) klossi Alex., 280.
(Libnotes) **melancholica** Alex., 278, 279.
(Libnotes) neofamiliaris Alex., 277, 279.
(Libnotes) perrara Alex., 279, 280.
(Libnotes) subfamiliaris Alex., 277, 279.
(Libnotes) terræ-reginæ Alex., 280.
(Libnotes) **unistriolata** Alex., 276, 279.
(Limnobia), 16, 282.
Limonia—Continued.
(Limonia) **atroaurata** Alex., 450.
(Limonia) **bagobo** Alex., 452.
(Limonia) **bilan** Alex., 449, 450.
(Limonia) **bilobulifera** Alex., 273, 274.
(Limonia) **candidella** Alex., 11, 12.
(Limonia) **canis** Alex., 14, 15, 452.
(Limonia) cynotis Alex., 452.
(Limonia) **flavohumeralis** Alex., 13, 14.
(Limonia) **latiflava** Alex., 12, 13.
(Limonia) luteivittata Alex., 276.
(Limonia) **melanopleura** Alex., 274, 275.
(Limonia) pacata Alex., 453.
(Limonia) prolixicornis Alex., 453, 454.
(Limonia) retrusa Alex., 14.
(Limonia) **subpacata** Alex., 453.
(Limonia) **subprolixa** Alex., 453, 454.
(Limonia) **tremula** Alex., 275, 276.
(Pseudoglochina) **angustapicalis** Alex., 20, 21.
(Pseudoglochina) unicinctipes Alex., 21.
(Rhipidia) **luteipleuralis** Alex., 16.
(Rhipidia) morionella (Edw.), 15, 16.
(Thrypticomyia) apicalis (Wied.), 27.
Limoniinæ, 11, 273, 447.
Limoniini, 11, 273, 447.
Lindsaya apoensis, 216.
longa Copel., 216.
macraeana, 216.
merrillii, 216.
protracta, 216.
Linospora elasticae Koord., 507.
pandani Rehm, 507.
seriata (Syd.) Rehm, 507.
Lipophleps, 31.
Lisea revocans Sacc., 492.
Litsea glutinosa, 486, 531.
mollis, 486.
Livistona, 514, 536.
Lomariopsis smithii Fée, 216.
LOPEZ, A. W., The fly Eutrixopsis javana Townsend (Diptera, Tachinidæ), a parasite of the beetle Leucopholis irrorata in Occidental Negros, Philippine Islands, 129; The use of the antennae as a means of determining the sexes in Leucopholis irrorata adults (Coleoptera, Scarabæidæ), 759; *see also* HADDEN and LOPEZ.
Lophodermium aleuritis Rehm, 514.
arundinaceum (Schrad.) Chev., 514.
arundinaceum (Schrad.) Chev. f. vulgare Fckl., 514.
passiflorae Rehm, 514.
planchoniae Rehm, 515.
rotundatum Syd., 515.
Loranthomyces sordidula (Lev.) v. Hoehn., 490.
Loranthus haenkeani, 490.
sp., 490.
Lucidium pythiodes, 518.
Lycogala epidendrum Fries, 85, 90.
Lycopersicum esculentum, 518, 519, 536.

Lycopodium delbrueckii, 209.
edañoi Copel., 209.
phlegmarioides, 209.

M

Macaranga, 536.
tanarius, 486.
utilis, 529.
sp., 488, 529.
Macrophoma arengae Sacc., 522.
cyanopsidis Syd., 522.
musae (Cke.) Berl. & Vogl., 522.
obsoleta Sacc., 523.
trichosanthis Syd., 523.
Malaria, avian, 305, 347, 651.
transmission in the Philippines, III, 47; IV, 247; V, 363; VI, 371.
Mallotus philippinensis, 488, 511.
Malpighia, 506.
MANALANG, C., Origin of the irritating substance in mosquito bite, 39; Malaria transmission in the Philippines, III, 47; IV, 247; V, 363; VI, 371.
Manchuria, China, Mycetozoa from north, 85.
Mangifera indica, 486, 509, 510, 527, 529, 532.
Manihot dichotoma, 525.
utilissima Pohl, 504, 521, 524, 528, 531, 532, 627.
Marchalia, 495.
constellata (Berk. & Br.) Sacc., 495.
spurcaria, 495.
Marsonia pavonina Syd., 529.
Massalongiella imperatae Rehm, 504.
Massaria bataanensis Rehm, 509.
Massariaceæ, 509.
Massarina raimundoi Rehm, 509.
Massarinula bambusicolæ Rehm, 509.
donacina Rehm, 509.
obliqua Sacc., 509.
Mealybug, pink, efforts toward biological control of the common, of sugar cane on Negros, 221.
Megalonectria pseudotrichia (Schw.) Speg., 491.
Megistomastix Alex., 270.
nigromaculata Edw., 270.
Melampsoraceæ, 481.
Melanconiaceæ, 527.
Melanconiales, 527.
Melanconidaceæ, 511.
Melanconium sacchari Cke., 529.
Melanomma mindorense Rehm, 501.
Melanopsamma lichenoides Rehm, 501.
Melastoma, 527.
fuscæ, 498.
Melia azedarach, 533.
Meliola affinis Syd., 485.
aliena Syd., 485.
alstoniae Koord., 485.
apayaoensis Yates, 486.
arachnoidea Speg., 485.
arundinis Pat., 485.
bakeri Syd., 485.
callicarpae Syd., 485, 536.
callista Rehm, 485.
citricola Syd., 485.
clerodendricola P. Henn., 485.
cookeana Speg. var. saccardoi Syd., 486.
cylindrophora Rehm, 486.
desmodii Karst. & Roum., 486.
dichotoma Berk. & Cke., 486.
elmeri Syd., 486.
gymnosporiae Syd., 486.
hewittiae Rehm., 486.
hyptidis Syd., 486.
intricata Syd., 486.
macarangae Syd., 486.
maesae, 492.
mangiferae Earle, 486.
merremiae Rehm, 486.
merrillii Syd., 486.
micromera Syd., 485.
mitragynes Syd., 486.
panici Earle, 486.
parenchymatica Gaill., 487.
perpusilla Syd., 487.
piperina Syd., 487.
polytricha Kalch. & Cke., 487.
quadrispina Rac., 487.
sandorici Rehm, 487.
sidae Rehm, 487.
substenospora v. Hoehn. f. rottboelliae Rehm, 487.
tamarindi Syd., 487.
telosmae Rehm, 487.
uncariae Rehm, 487.
sp., 489.
Melogrammataceæ, 511.
Memecylon lanceolatum, 489.
subfurfuraceum, 489.
sp., 485.
MENDIOLA, N. B., Somatic segregation in double Hibiscus and its inheritance, 627.
Merremia hederacea, 486.
umbellata, 487.
sp., 489.
Merrilliopeltis calami P. Henn., 490.
daemonoropsis Syd., 490.
hoehnelii Rehm, 490.
Mesoderes Senna, 398, 433, 437.
fessus Kln., 386, 398, 400, 437.
Mesomyites Ckll., 294.
Metasphaeria corruscans Rehm, 508.
incompletæ Rehm, 508.
maculans, 501.
Metatrachelizus Kln., 406, 434, 438.
constans Kln., 387, 406, 416, 438.
Microdiplodia passeriniana (Thum.) Allesch., 523.
Microdothella culmicola Syd., 495.
Micropeltella consimilis Rehm, 491.
Micropeltis aeruginascens Rehm, 491.
mucosa Syd., 491.

Microthyriaceæ, 488.
Microthyriella latemaculans (Rehm) Theiss. & Syd., 491.
philippinensis Syd., 491.
Microthyrium, 496.
Microtrachelizus Senna, 413, 414, 434, 440.
flexus Kln., 417.
fluxus Kln., 388, 413, 440.
pubescens Senna, 388, 413, 417, 440.
siamensis Kln., 38, 413, 417, 440.
tabaci Senna, 388, 413, 417, 440.
Microxyphium dubium Sacc., 488.
Milletia, 499.
cavitensis, 499.
Miolispa Pasc., 407, 410, 412, 431, 434, 438.
bicolor Kln., 387, 407, 416, 439.
clavicornis Kln., 387, 407, 416, 439.
cruciata Senna, 387, 407, 416, 439.
discors Senna, 387, 407, 416, 439.
elongata Kln., 387, 408, 410, 416, 439.
ephippium Kln., 387, 408, 416, 439.
flavolineata Kln., 387, 408, 416, 439.
flexilis Kln., 387, 408, 416, 439.
formosa Kln., 387, 408, 416, 439.
fornicata Kln., 387, 408, 416, 439.
fraudatrix Kln., 387, 409, 416, 438.
intermedia Senna, 387, 409, 416, 439.
lineata Senna, 387, 409, 416, 439.
pascoei Kln., 387, 409, 416, 439.
paucicostata Kln., 387, 409, 416, 438.
persersimilis Kln., 388.
persimilis Kln., 409, 416, 438.
pulchella Kln., 388, 410, 416, 438.
robusta Kln., 388, 410, 416, 439.
siporana Senna, 388, 410, 416, 439.
unicolor Kln., 388, 410, 416, 438.
Miscanthus japonicus, 514.
Mischocarpus fuscescens, 509, 535.
Mitopeza Edw., 270.
longicornis Brun., 270, 272.
mjöbergi Edw., 270, 272.
nigromaculata (Edw.), 272.
nitidirostris (Edw.), 270, 272.
rizalensis Alex., 270, 272.
Mitragyne rotundifolia, 486.
Mollisia ravida Syd., 515.
Mollisiaceæ, 515.
Molophilus banahaoensis Alex., 289, 290.
kempi Alex., 289, 290.
mendicus Alex., 292, 293.
procericornis Alex., 290, 292.
tawagensis Alex., 293, 294.
Momordicæ sp., 485.
Moniliformidæ Van Cleave, 582.
Moniliformis Travassos, 582.
moniliformis (Bremser) Travassos, 582, 584.
MONSERRAT, CARLOS, The Kahn test in clinical syphilis, 225; Comparative serologic study of Vernes, Wassermann, and Kahn reactions in experimental treponematoses, 241.
Morenoella breviuscula, 490.
memecyli Syd., 489.
Morus alba, 482, 484, 511, 520, 522, 526.
albus, 482.
Mosquito bite, origin of the irritating substance in, 39.
Mosquitoes, Anopheles, daytime resting places of, in the Philippines, 639.
Moth, meal, 555.
Mucedinaceæ, 530.
Mucoraceæ, 520.
Mucuna deeringiana, 481, 532.
nivea, 481.
Munkiella, 498.
Munkiodothis melastomata (v. Hoehn.) Theiss. & Syd., 498.
Mus decumanus Pallas, 537.
norvegicus Erxleben, 537, 569, 584.
Musa cavendishii, 504.
paradisiaca sapientum, 504, 516, 523, 535.
sapientum, 504, 516, 521, 522, 529, 535.
textilis, 504, 520, 523, 530, 535.
sp., 521.
Mycelia sterilia, 536.
Mycetozoa from north Manchuria, China, 85.
Mycobacterium lepræ, 123, 611–615, 616–623.
Mycochytridiaceæ, 518.
Mycogne cervina Ditm. var. theobromae Sacc., 530.
Mycorales, 520.
Mycosphaerella alocasiae Syd., 504.
aristolochiae Syd., 504.
brideliae Syd., 504.
caricae Syd., 504.
musae Speg., 504.
oculata Syd., 504.
pericampyli Syd., 505.
reyesii Syd., 505.
Mycosphaerellaceæ, 503.
Myiocoprella bakeri Sacc., 491.
Myiocopron bakerianum Rehm, 491.
Myocopron, 497.
Myriangiales, 517.
Myriangium duriaei Mont., 517.

N

Navicula kariana Grun. var. minor Grun. forma curta Cleve, 113.
kariana Grun. var. minor Grun. forma japonica Skv., 113.
pellucida Karst., 112.
(Cistula) lorenziana Grun., 112.
(Schizonema) mollis W. Sm., 113.
(Schizonema) ramosissima Agardh forma amplia Grun., 113.
Nectria bainii Mass., 492.
bainii Mass. var. hypoleuca Sacc., 492.
discophora Mont., 492.
striatospora, 492.
subfurfuracea P. Henn. & Nym., 492.
tjibodensis Penz. & Sacc. var. gliricidiae Rehm, 492.
Nectriaceæ, 491.

Nectrioidaceæ, 526.
Nemathelminthes Vogt, 560.
Nematoda Rudolphi, emend. Diesing, 560.
Nematode, 585.
Nematodes, 538, 584.
Nemocephalini, 433.
Neolitsea, 517.
Neopeckia rhodosticta (B. & Br.) Sacc., 502.
rhodosticta (Berk. & Br.) Sacc. var. magnifica Rehm, 502.
Nesopeza Alex., 269, 270.
gracilis, 269.
Nicotiana tabacum, 518, 532, 536.
Nipa fruticans, 490, 496, 509.
Nippostrongylus Lane, 567.
muris (Yokogawa) Lane, 538, 560, 567, 584.
Niptera grewiae Rehm, 515.
Nitschkea bambusarum Rehm, 503.
Nitzchiella longissima (Bréb.) Ralfs forma parva V. Heurck, 81, 115.
Nitzschia birostrata Sm., 115.
Nummularia citrincola Rehm, 513.
fragillima Rehm, 513.
glycyrrhiza (B. & C.) Sacc., 513.
lianae Rehm, 513.
memorabilis Rehm, 513.
papyracea Rehm, 513.
reyesiana Rehm, 513.
scutata B. & C., 513.
urceolata Rehm, 513.

O

Oidium erysiphoides Fr., 530.
Oil, kapok-seed, composition of, 131.
Philippine peanut, composition of, 199.
Philippine pine-needle, from Pinus insularis (Endlicher), 1.
Oils, hydnocarpus-group, causes of irritation upon injection of iodized ethyl esters of, 377.
Oleandra benguetensis Copel., 217.
chinensis Hance, 218.
colubrina, 217.
cumingii Presl., 217, 218.
macrocarpa Presl., 217, 218.
maquilingensis, 217.
mollis, 217.
neriiformis, 217.
scandens Copel., 217, 218.
whitneii, 217.
OLIVER, WADE W., WALFRIDO DE LEON, and ALFREDO PIO DE RODA, The attempted cultivation of Mycobacterium lepræ, 611.
Oomycetes, 517.
Oospora candidula Sacc., 530.
hyalinula Sacc. var. sordidula Sacc., 530.
oryzetorum Sacc., 530.
Operculina turpethum, 483.
Ophiobolus, 507.
heterostrophus Drechsler, 509.
nipae Henn., 509.
oryzae I. Miyake, 509.
oryzinus Sacc., 509.
Ophiochaete bakeriana Sacc., 508.
Ophiodothis thanatospora (Lev.) Rac., 493.
Ophionectria erinacea Rehm, 492.
theobromae (Pat.) Duss., 492.
Opisthenoplus Kln., 427, 435, 442.
calabresii Kln., 389, 427, 432, 442.
cavis F. Walk., 389, 427, 428, 432, 442.
fascinatus Kln., 389, 428, 432, 442.
fecundus Kln., 389, 428, 432, 442.
madens Lac., 389, 428, 432, 442.
Opisthenoxys Kln., 397, 433, 437.
boettcheri Kln., 386, 397, 400, 437.
Orania palindan, 535.
Orchidaceæ, 481, 491, 529.
Origin of the irritating substance in mosquito bite, 39.
Orimarga rubricolor, 23.
(Orimarga) **rubricolor** Alex., 22.
Oropeza Needham, 270.
Orthopareia Kln., 396, 433, 436.
idonea Kln., 386, 396, 400, 436.
Oryza sativa, 484, 494, 501, 509, 518, 525, 530, 533, 534, 536.
Oxyuridæ Cobbold, 569.
Oxyuroidea Railliet, 569.
Ozonium glumicola Sacc., 536.

P

Pachypatella alsophilae (Rac.) Theiss. & Syd,. 515.
Pachyrrhizus angulatus, 482.
erosus, 482.
Paederia foetida, 483.
tomentosa, 483.
Pahudia rhomboidea, 499, 532.
Palawania cocoes Syd., 495.
grandis (Niessl.) Syd., 496.
Palmularia, 496.
Pandanus, 490, 502, 506.
copelandi, 490.
luzonensis, 495.
radicans, 506.
sabutan, 502, 505, 507.
tectorius, 494.
utilissima, 507.
Panicum, 481, 492.
auritum, 534.
indicum, 484.
repens, 481.
sp., 492, 494.
Paramorphocephalus Kln., 418, 434, 440.
setosus Kln., 388, 418, 440.
Paranectria luxurians Rehm, 492.
Parasite of the beetle Leucopholis irrorata in Occidental Negros, Philippine Islands, 129.

Parasites, worm, of the brown rat (Mus norvegicus) in the Philippine Islands, 537.
Parkia javanica, 499.
timoriana, 499.
Parodiella grammodes (Kze.) Cke., 487.
Passiflora quadrangularis, 491, 526.
Patellariaceæ, 515.
Pavetta indica, 482.
Payena leeri, 509.
Pazschkiella philippinensis Yates, 523.
Peanut oil, composition of, 199.
Pelagic diatoms of Korean strait of the Sea of Japan, 95.
Pennisetum, 499.
Peragallia meridiana Schütt, 106.
Pericampylus incanus, 505.
Perichaena depressa Libert, 85, 92.
Periconia philippinensis Sacc., 534.
Periplaneta americana, 578, 583.
Perisporiaceæ, 485.
Perisporiales, 484.
Peroneutypella arecae Syd., 510.
graphidioides Syd., 510.
Peronospora, 519.
Peronosporaceæ, 519.
Peronosporales, 519.
Persea americana, 509, 536.
gratissima, 536.
Pestalozzia funerea Desm., 529.
palmarum Cke. & Grev., 529.
pauciseta Sacc., 529.
Pezizaceæ, 516.
Pezizales, 515.
Pezizella ombrophilacea Rehm, 516.
Phacidiaceæ, 517.
Phacidiales, 517.
Phacidium, 495.
Phakospora pachyrhizi Syd., 482.
phyllanthi Diet., 482.
Phaodothis gigantochloae, 508.
Phaseolus aureus, 531.
calcaratus, 499.
lunatus, 522, 532, 533.
mungo, 481, 484.
vulgaris, 520, 522.
sp., 499, 531.
spp., 481, 508, 517, 528, 523.
Phellestroma hypoxyloides Syd., 524.
Phenacuspis mischocarpi, 535.
Philippine Anopheles gigas and Anopheles lindesayi, varieties of, 751.
Coriaria, 257.
fresh-water sponges, 61.
kapok-seed oil, 131.
peanut oil, composition of, 199.
pine-needle oil from Pinus insularis (Endlicher), 1.
rat-bite fever, 159.
Tipulidæ, 9, 269.
Phoma bakeriana Sacc., 523.
citricarpa McAlpine, 523.
herbarum Westd., 524.
Phoma—Continued.
musae Carpenter, 522.
oleracea Sacc., 524.
sabdariffae Sacc., 524.
sesamina Sacc., 524.
solanophila Oud., 524.
Phomatospora migrans Rehm, 510.
Phomopsis arecae Syd., 524.
calanthes Sacc., 523.
capsici (Magnaghi) Sacc., 523.
cinerescens (Sacc.) Bubák, 523.
dioscoreae Sacc., 523.
gliricidiae Syd., 523.
palmicola (Wint.) Sacc. f. arecae Sacc., 524.
Phragmitis karka, 486.
vulgaris, 485.
Phycomycetes, 517.
Phyllachora, 495, 497, 498.
afzeliae Syd., 498.
canari P. Henn., 498.
circinata var. sanguinea, 498.
coicis P. Henn., 498.
cynodontis (Sacc.) Niessl., 499.
dalbergiae Niessl., 499.
dioscorea Schw., 499.
fici-fulvae, 497.
fici-minahassae, 497.
ficuum, 501.
luzoniensis P. Henn., 499.
minutissima (Welw. & Curr.) Sm., 499.
orbicula Rehm, 499.
pahudiae Syd., 499.
parkiae P. Henn., 499.
phaseolina Syd., 499.
pongamiae (Berk. & Br.) Petch., 499.
pterocarpi non Rehm, 498.
pterocarpi Rehm non Syd., 500.
rehmiana Theiss. & Syd., 499.
rottboelliae Syd. & Butl., 499.
roureae Syd., 499.
sacchari P. Henn., 500.
sacchari-spontanei Syd., 500.
sorghi v. Hoehn., 500.
spinifera, 497.
tjankorreh Rac., 500.
yapensis (P. Henn.) Syd., 500.
Phyllachoraceæ, 496.
Phyllactinia suffulta (Rebent.) Sacc., 484.
Phyllanthus niruri, 482.
reticulatus, 488.
sp., 482.
Phyllodromia germanica, 556, 575, 578.
Phylloporina phyllogena Muel.-Arg., 494.
Phyllosticta circumsepta Sacc., 524.
cocophylla Pass., 524.
densissima Sacc., 524.
dysoxyli Sacc., 524.
euchlaenae Sacc., 525.
glumarum Sacc., 525.
graffiana Sacc., 525.
insularum Sacc., 525.
manhoticola Syd., 525.
miurai I. Miyake, 525.

Physalospora, 497.
affinis Sacc., 508.
bambusae (Rabh.) Sacc., 508.
bambusicola Rehm, 508.
dinochloae Rehm, 508.
guignardioides Sacc., 508.
hoyae v. Hoehn., 508.
peribambusina Rehm, 509.
Physarum, 86.
asiaticum Skv., 85, 87.
compressum Skv., 85, 86.
griseum Skv., 85, 86.
mandshuricum Skv., 85, 87.
Phytophthora colocasiae Rac., 519.
faberi Maubl., 519.
infestans (Mont.) de Bary, 519.
melongenae K. Sawada, 519.
phaseoli Thaxter, 519.
theobromae, 519.
Picea vulgaris, 4.
Pilaria, 27.
alboposticata Alex., 28.
carbonipes Alex., 27, 28.
carbonipes **holomelania** Alex., 28.
melanota Alex., 28.
phœnosoma Alex., 25, 26.
Pilobolaceæ, 520.
Pilobolus lentiger Cda., 520.
Pilobus kleinii var. sphaerospora, 520.
Pilocratera tricholoma (Mont.) P. Henn., 516.
Pinanga, 488.
Pine-needle oil, Philippine, from Pinus insularis (Endlicher), 1.
Pinus contorta, 4.
excelsæ, 4.
halepensis, 4.
insularis Endl., 1, 4.
lambertiana, 4.
longifolia, 4.
ponderosa, 4.
pumilis, 4.
sabiniana, 4.
sylvestris, 4.
Pionnotes capillacea Sacc., 536.
Piper retrofractum, 485.
sp., 487.
Pipturus arborescens, 489, 502.
Pittosporum pentandrum, 486.
sp., 486.
Placosphaeria duriones Syd., 525.
tiglii Henn., 525.
Placostroma pterocarpi (Mass.) Theiss. & Syd., 500.
Planchonia spectabilis, 515.
Plankton diatoms from Vladivostok Bay, 77.
Planktoniella sol (Wall.) Schütt, 97.
PLANTILLA, FIDEL C., *see* RODRIGUEZ and PLANTILLA.
Plasmochin, prophylactic, in inoculated avian malaria, 305.
prophylactic, versus prophylactic quinine in inoculated avian malaria, 347.
Plasmodium cathemerium Hartm., 306, 308, 334, 347, 360, 656, 657.
Platyhelminthes Claus, 539.
Plectronia, 479.
didyma, 485.
horrida, 479.
Pleosporaceæ, 507.
Pleurosigma arcuatum Donk., 81.
balticum var. wansbeckii Donk., 118.
fasciola Ehreb. var. arcuatum Donk., 81.
longum Cleve var. inflata Per. forma **japonica** Skv., 113.
wansbeckii Donk., 113.
Plicaria bananincola Rehm, 516.
tropica Rehm, 516.
Podocarpus, 503.
costatus, 503.
Polygonum chinensis, 480.
tomentosum, 480.
Polyosma philippinensis, 527.
sorsogonensis, 527.
Polyphragma, 467.
Polypodium alpestre Blm., 219.
bulbotrichum Copel., 219.
Polyporus, 516.
sanguineus, 193.
Polyscias nodosa, 512.
Polystomellaceæ, 494.
Pongamia glabra, 499.
mitis, 499.
pinnata, 499.
Popillia japonica, 129.
Populus simonii, 92.
Pothoideum lobbianum, 490.
Prairie dog, 564.
Premna, 516.
cumingiana, 484, 507, 508.
odorata, 485, 493, 504, 507, 515.
vestita, 484.
sp., 489, 504.
Prophthalmus Lac., 419, 435, 441.
longirostris Gyll., 388, 419, 422, 441.
tricolor Power, 388, 419, 422, 441.
Propolidiopsis arenga Rehm, 517.
Prosostomata Odhner, 539.
Proteosoma, 656.
Protospirura Seurat, 573.
columbiana Cram, 575.
muricola Gedoelst, 538, 573, 584.
muris (Gmel.), 575.
Pseudoceocephalini, 390, 427, 432, 433, 435, 442.
Pseudocyphagogus Desbr., 397, 433, 437.
squamifer Desbr., 386, 397, 400, 437
Pseudorychodes Senna, 421, 435, 441.
præclarus Kln., 389, 421, 422, 441.
Pseudothis pterocarpi Syd., 494.
Psidium guajava, 487, 511, 516, 527.
Psophocarpus, 518.
tetragonolobus, 518.
Psychotria luzoniensis, 495, 496.
Pterocarpus angalensis, 498.
indicus, 498.
sp., 515.

Puccinia citrata Syd., 480.
congesta Berk. & Br., 480.
engleriana P. Henn., 480.
erebia Syd., 480.
heterospora Berk. & Curt., 480.
kuehnii (Krueg.) Butl., 480.
merrillii P. Henn., 480.
paullula Syd., 480.
philippinensis Syd., 480.
purpurea Cke., 480.
thwaitesii Berk., 480.
Pucciniaceæ, 479.
Pucciniostele clarkiana (Barcl.) Diet., 480.
Pueraria, 518.
sp., 532.
Pycnocrepis End., 294.
Pythiaceæ, 518.
Pythium autumnale, 518.
debaryanum Hesse, 518.
esquiseti, 518.
vexans, 518.

Q

Quercus sp., 534.
Quinine, prophylactic, in inoculated avian malaria, 347.

R

Raillietina Fuhrmann, 538, 548, 552.
celebensis (Janicki) Meggitt & Subramanian, 549, 585.
fluxa Meggitt & Subramanian, 586.
funebris Meggitt & Subramanian, 586.
garrisoni Tubangui, 538, 548, 549, 584–586.
Ramularia catappae Rac., 530.
Rat, brown, worm parasites of, in the Philippine Islands, 537.
fleas, 556.
Rat-bite fever in the Philippines, 159.
Rhabdiasidæ Railliet, 560.
Rhabdiasoidea Railliet, 560.
Rhabdospora synedreliae Sacc., 525.
Rhagadolobium bakerianum Sacc., 517.
Rhampholimnobia reticularis Alex., 23.
Rhipidia (Rhipidia) morionella Edw., 15.
Rhipidocarpon javanicum (Pat.) Theiss. & Syd., 496.
Rhizopus artocarpi Rac., 520.
nigricans Ehrbg., 520.
Rhizosolenia, 92.
alata Brightw., 114.
alata Brightw. forma gracillima (Cleve) Grun., 81, 114.
(alata var.) gracillima Cleve, 114.
flaccida Castr., 114.
hyalina Ostenf., 115.
japonica Castr., 114.
robusta Norman, 115.
setigera Brightw., 81, 114.
sigma Schütt, 115.
Rhododendron schadenbergii, 490.
sp., 490.
Rhopographella reyesiana Rehm, 500.
Rhopographus, 498.
Rhyticephalini, 433.
Rhytisma lagerstroemia Rabh., 517.
pongamiae, 517.
spurcarium, 495.
Ricinus communis, 518, 520, 522.
Rictularia Froelich, 538, 579, 580, 585.
tani, 585.
whartoni Tubangui, 538, 579, 584, 585.
Rictulariidæ Railliet, 579.
Rictulariinæ Hall, 579.
RODA, ALFREDO PIO DE, *see* OLIVER, LEON and RODA.
RODRIGUEZ, JOSE, and FIDEL C. PLANTILLA, The histamine test as an aid in the diagnosis of early leprosy, 123.
Rosellinia bunodes (Berk. & Br.) Sacc., 502.
calami P. Henn., 502.
cocoes P. Henn., 502.
decipiens (Rehm) Theiss. & Syd., 502.
lamiprostoma Syd., 502.
megalosperma Syd., 502.
merrillii Syd., 502.
molleriana Henn., 502.
procera Syd., 503.
umbilicata Sacc., 503.
(Conimela) maquilingiana Rehm, 502.
(Tassiella) crustacea Rehm, 502.
(Tassiella) horrida Rehm, 502.
Rottboellia exaltata, 484, 486, 487, 499.
Rourea erecta, 491, 499.
Rubus moluccanus, 480.
RUSSELL, PAUL F., Avian malaria studies, I. Prophylactic plasmochin in inoculated avian malaria, 305; Avian malaria studies, II. Prophylactic plasmochin versus prophylactic, quinine in inoculated avian malaria, 347; Daytime resting places of Anopheles mosquitoes in the Philippines: First report, 639; Avian malaria studies, III. The experimental epidemiology of avian malaria; introductory paper, 651.
Rhytisma, 495.
constellatum, 495.

S

Saccharum officinarum, 480, 484, 485, 496, 500, 519, 520, 528–530, 533.
spontaneum, 500, 525, 529, 535.
Sandoricum indicum, 519.
koetjape, 487, 519.
SANTOS, IRENE DE, AUGUSTUS P. WEST, and P. D. ESGUERRA, Philippine pine-needle oil from Pinus insularis (Endlicher), 1.
SANTOS, JOSÉ K., Leaf and seed structure of a Philippine Coriaria, 257.

Sapindus saponaria, 505.
sp., 487.
Sarcinella raimundoi Sacc., 534.
Scamboneura O. S. 10, 271.
calianensis Alex., 10.
nigrotergata Alex., 9–11.
vittivertex Alex., 10.
Scarabæidæ, 578, 759.
Scaurus striatus, 556.
Sceletonema costatum (Grev.) Cleve, 77.
Schizochora elmeri Syd., 500.
Schizœupsalis, 420.
Schizonema albicans V. Heurck, 113.
amplius V. Heurck, 113.
torquatum V. Heurck, 113.
Schizostachyum, 493, 497, 502, 503, 505–507, 510, 512.
acutiflorum, 500, 536.
lumampao, 510.
rotundifolium, 500.
sp., 500, 512, 533.
Schizothyrium aceris (P. Henn. & Lind.) Pat., 515.
Schizotrachelus Lac., 429, 431, 435, 443.
agulaticeps Senna, 389, 429, 432, 443.
bakeri Kln., 389, 429, 432, 443.
bakeri Kln., f. concolor, 429, 443.
brevicaudatus Lac., 390, 430, 432, 443.
brunneus Kln., 390, 430, 432, 443.
consimilis Kln., 390, 430, 432, 443.
corpulentus Kln., 390, 430, 432, 443.
imbricellus Kln., 390, 430, 432, 443.
imitator Kln., 390, 430, 432, 443.
inconstans Kln., 390, 430, 432, 443.
Schlerospora spontanea Weston, 519.
Schneepia, 496.
hymenolepidis (P. Henn.) Theiss. & Syd., 496.
SCHÖBL, OTTO, An interpretation of the laws of Brown and Pearce that govern the course of treponematoses, 169; Coexistent infection with yaws and syphilis, 177; The prospects of vaccination and vaccine therapy in treponematoses, 183.
Schroederella delicatula (Per.) Pavil., 99.
Schroeteriaster cingens Syd., 481.
Scirpus grossus, 486.
Scirrhia, 494, 500.
bambusina Penz. & Sacc., 500.
luzonensis P. Henn., 500.
Scirrhodothis bambusina (Penz. & Sacc.) Theiss. & Syd., 500.
seriata Syd. & Butl., 500.
Sclerospora maydis (Rac.) Butl., 519.
philippinensis Weston, 519.
sacchari Miyake, 519.
Sclerotinia nervisequia Schroet. v. bambusacea Rehm, 516.
Sclerotium rolfsii Sacc., 536.
Scymnus sp., 221.
Septogloeum arachidis Rac., 529.
Septonema philippinum Sacc., 535.
Septoria palmarum Sacc., 525.
Septosporiella philippinensis Sacc., 525.
Serinus canarius, 656.
Sesamum indicum, 524, 526, 528, 529, 532.
orientale, 524, 526, 529, 532.
Sexes, determination of, in Leucopholis irrorata adults by use of antennæ, 759.
Seynesia, 496.
alstoniae Rehm, 489.
calamicola, 496.
ipomoeae Syd., 489.
Shorea guiso, 195.
sp., 489.
Sida acuta, 487.
carpinifolia, 487.
javensis, 480.
Sideroxylon ferrugineum, 489.
sp., 489.
Skeleton of the timarau, 141.
SKVORTZOW, B. W., Pelagic diatoms of Korean strait of the Sea of Japan, 95; Plankton diatoms from Vladivostok Bay, 77.
Smilax bracteata, 480.
reticulata, 480.
Solanum melingena, 519, 522, 524, 532, 534.
tuberosum, 519.
Somatic segregation in double Hibiscus and its inheritance, 627.
Sordaria oryzeti Sacc., 501.
Sordariaceæ, 501.
Sorghum vulgare, 480, 484, 488, 500, 507, 534.
sp., 500.
Spegazzinia meliolae A. Zimm., 536.
ornata Sacc., 536.
Sphaeria, 492, 494, 496, 502, 506, 508.
Sphaeriaceæ, 501.
Sphaeriales, 501.
Sphaerioidaceæ, 520.
Sphaeriopsidales, 520.
Sphaerophragmium luzonicum Yates, 481.
Sphaerulina smilacincola Rehm, 505.
Spirillum minus, 165.
Spirochæta morsus muris, 159, 165.
Spiroptera neoplastica Fibiger & Ditlevsen, 575.
Spiroxyinæ Baylis & Lane, 573.
Spiruridæ Oerley, 573.
Spiruroidea Railliet & Henry, 573.
Sponges, fresh-water, of the Philippine Islands, 61.
Spongilla alba, 64.
clementis Annandale, 61, 65–69.
lacustris, 71.
microsclerifera Annandale, 61, 69.
philippinensis Annandale, 61, 62, 64–67, 69.
sceptrioides, 64, 68.
yunnanensis, 65.
Sporobolus elongatus, 534.
sp., 534.
Sporodesmium bakeri Syd., 534.

Stagonospora varians Sacc., 525.
Stemonitis herbatica Peck., 85, 89.
splendens, 85.
splendens Rost. var. flaccida Dister, 88.
Stenochlaena leptocarpa, 216.
smithii (Fée) Underwood, 216.
Stephanopyxis, 95.
appendiculata Ehrenb., 98.
campana Castr., 98.
palmeriana (Grev.) Grun., 98.
palmeriana forma curta Alex., 98.
palmeriana var. japonica, 98.
turris (Grev. & Arn.) Ralfs, 98.
var. javanica Grun., 98.
Sterculia, 506.
Stereodermini, 390, 399, 431, 433, 434, 437.
Stereodermus Lac., 401, 434, 437.
flavotibialis Kln., 387, 401, 437.
STEVENS, F. L., ed. Second supplement to the list of the lower fungi of the Philippine Islands, 479.
Stictidaceæ, 517.
Stigmatodothis palawanensis Syd., 496.
Stigmella manilensis Sacc., 535.
Stizolobium deeringianum, 481, 532.
niveum, 481, 532.
Streblus asper, 502, 511, 515.
Strobilocercus, 546.
fasciolaris Sambon, 546.
Strongyloidea Weinland, 567.
Strongyloides Grassi, 560.
papillosus (Wedl) Hall, 560.
ratti Sandground, 538, 560, 584.
stercoralis, 561.
Styringomyia Loew, 294.
acuta Edw., 298.
armata Edw., 294, 297, 298.
ceylonica Edw., 295, 300.
claggi Alex., 294, 297.
colona Edw., 302.
ensifera Edw., 298.
flava Brun., 296.
flavocostalis Alex., 295, 299.
fumipennis Edw., 294, 295.
luteipennis Alex., 294–297.
megregori Alex., 294, 295.
montina Alex., 294, 296.
neocolona Alex., 295, 301.
nigrosternata Alex., 295, 299, 300.
tablasensis Alex., 295, 300.
taiwanensis Alex., 296.
SUMULONG, MANUEL D., The skeleton of the timarau, 141.
Surirella gemma Ehrenb. var. ovata Skv., 116.
Symplocum whitfordii, 525.
Synchytriaceæ, 517.
Synchytrium, 518.
aecidioides, 518.
decipiens, 518.
fulgens var. decipiens, 518.
Synedra, 77.
affinis Kutz. var. gracilis Grun., 81.
auriculata Karst., 112.
japonica Skv., 81.
Synedra—Continued.
koreana Skv., 112.
nitzschioides Grun., 110.
Synedrella nodiflora, 522, 525, 526.
Syphacia Seurat, 569.
obvelata (Rudolphi) Seurat, 538, 560, 584.
Syphaciinæ Railliet, 569.
Syphilis, coexistent infection with yaws and, 177.
Kahn test in clinical, 225.

T

Tabernaemontana campanulata, 480.
polygama, 483.
Tachinidæ, 129.
Tænia Linn., 546.
ægyptiaca Bilharz, 556.
crassicollis Rudolphi, 546.
diminuta (Rudolphi), 553.
flavomaculata Leuckart, 553.
madagascariensis Leuckart, 585.
murina Dujardin, 556.
tæniaformis (Batsch) Wolffhügel, 538, 546, 584.
Taeniidæ Ludwig, 546.
Taeniinæ Stiles, 546.
Tænioidea Zwicke, 546.
Talauma villariana, 506.
Tamarindus indica, 487.
Taphroderini, 433.
Teleneura Alex., 286, 287.
Telosma sp., 487.
Tenebrio molitor, 556.
Tenebrionidæ, 578.
Tephrosticta ficina Syd., 509.
Terminalia catappa, 510, 530.
Tetracera sp., 495.
Tetrastigma, 517.
sp., 485.
Teucholabis (Teucholabis) confluenta Alex., 36.
(Teucholabis) confluentoides Alex., 36.
(Teucholabis) majuscula Alex., 35, 36.
(Teucholabis) nigerrima Edw., 36.
Thalassiosira clevei Gran, 99.
gravida Cleve, 99.
hyalina (Grun.) Gran, 98.
nordenskioldii Cleve, 99.
Thalassiothrix antarctica Schimper, 80.
antarctica Schimper forma japonica Skv., 110.
curvata Castr., 110.
frauenfeldi Cleve, 110.
frauenfeldi var. nitzschioides, 111.
frauenfeldii Grun., 80, 111.
frauenfeldii (Grun.) Castr., 111.
nitzschioides Grun., 80, 110.
nitzschioides var. javanica Grun., 111.
Thaumastoptera, 457.
(Taiwanita) calceata Mik, 457.
(Taiwanita) issikiana Alex., 457.
(Thaumastoptera) maculivena Alex., 456.

Theobroma, 519.
cacao, 492, 508, 511, 519, 522, 530, 536.
Thunbergia grandiflora, 535.
Thyridaria calamincola Rehm, 511.
eminens Rehm, 511.
tarda Bancroft, 511.
Tilletiaceæ, 484.
Timarau, skeleton of the, 141.
Tipulidæ from the Philippines (Diptera), X, 9; XI, 269; XII, 447.
Tipulinæ, 9, 269.
Torula dichroa Sacc., 535.
herbarum Lk., 535.
herbarum Lk. f. quaternella Sacc., 535.
Trabutia elmeri Theiss. & Syd., 501.
ficuum (Niessl.) Theiss & Syd., 501.
vernicosa Theiss. & Syd., 501.
Trachelizini, 390, 406, 431, 433, 434, 438.
Trachelizus Schoenh., 406, 434, 438.
bisulcatus F., 387, 406, 416, 438.
Trametes versatilis, 193.
Traversoa dothiorelloides Sacc. & Syd., 526.
excipuloides Sacc., 525.
excipuloides Sacc. & Syd. var. distans Sacc. & Syd., 526.
Trema amboinensis, 489.
orientalis, 489.
sp., 489.
Trematoda Rudolphi, 539.
Trematodes, 538, 584.
Trematosphaeria maquilingiana Rehm, 503.
maquilingiana Rehm var. schizostachyi Rehm, 503.
Trentepohlia, 473, 474.
brevifusa, 285.
riverai, 285.
(Anchimongoma) **apoicola** Alex., 475, 476.
(Anchimongoma) niveipes Edw., 476.
(Mongoma) **æquialba** Alex., 470, 471, 473, 474.
(Mongoma) æquinigra Alex., 471–473.
(Mongoma) **distalis** Alex., 284.
(Mongoma) luzonensis Edw., 471, 473, 474.
(Mongoma) **majuscula** Alex., 471, 473.
(Paramongoma) albitarsis (Dol.), 470.
(Paramongoma) banahaoensis Alex., 469, 470.
(Paramongoma) **chionopoda** Alex., 469, 470.
(Paramongoma) pusilla Edw., 470.
(Trentepohlia) festivipennis Edw., 475.
(Trentepohlia) **lætipennis** Alex., 474, 475.
(Trentepohlia) ornatipennis Brun., 474, 475.
(Trentepohlia) trentepohlii (Wied.), 27.
(Trentepohlia) venustipennis Edw., 475.
Treponema pallidum, 179, 241.
pertenue, 179, 241.
Treponematoses, experimental, comparative serologic study of Vernes, Wassermann, and Kahn reactions in, 241.
Treponematoses—Continued.
interpretation of the laws of Brown and Pearce that govern the course of, 169.
prospects of vaccination and vaccine therapy in, 183.
Triblidiaceæ, 516.
Trichia **asiatica** Skv., 85, 90.
contorta, 85.
contorta Rost. var. inconspicua **Lister**, 90.
persimilis Karst., 85, 90.
variæ Pers., 90.
Trichinella spiralis, 538.
Trichobelonium melioloides Rehm, 516.
Trichodolichopeza Alex., 270.
Trichonectria bambusicola Rehm, 493.
Trichophyton flava, 126.
Trichosanthes anguina, 523.
Trichosoma crassicauda **Bellingham**, 562.
muris decumani Rayer, 562.
Trichosomoides Railliet, 562.
crassicauda (Bellingham) Railliet, 538, 562, 564, 584.
Trichosomoididæ York & Maplestone, 562.
Trichosomoidinæ Hall, 562.
Trichosphaeria bambusicola Rehm, 503.
Trichosporium coccidicola Sacc., 535.
Trichostrongylidæ Leiper, 567.
Trichothyriaceæ, 490.
Trichothyrium orbiculare Syd., 489.
Trichuridæ Railliet, 564.
Trichuroideæ Railliet, 562.
Trionymus sacchari (Ckll.), 221.
Triumfetta sp., 485.
Tryblidiella mindanaensis P. Henn., 516.
rufula (Spreng.) Sacc., 516.
TUBANGUI, MARCOS A., Worm parasites of the brown rat (Mus norvegicus) in the Philippine Islands, with special reference to those forms that may be transmitted to human beings, 537.
Tuberculariaceæ, 535.
Tychaeini, 433.
Tylophora floribunda, 487.
perrottetii, 487.

U

Uleopeltis bambusina Syd., 496.
Ulocerini, 433.
Uncaria perrottetii, 487.
Uredinales, 479.
imperfecti, 482.
Uredo, 517.
arthraxonis-cillaris P. Henn., 483.
claoxyli Sacc., 483.
davaoensis Syd., 483.
desmium (Berk. & Br.) Petch., 483.
dioscoreae (Berk. & Br.) Petch., 483.
dioscoreae-alatae Rac., 483.
erythrinae P. Henn., 483.
fici Cast., 483.

Uredo—Continued.
kuehnii (Krueg.) Wakk. & Went., 480.
manilensis Syd., 483.
mori, 482.
moricola, 482.
ochracea Diet., 483.
operculinae Syd., 483.
peckii, 517.
premnae Koord., 484.
vignae Bres., 484.
Uromyces, 518.
appendiculatus (Pers.) Lk., 481, 484.
deeringiae Syd., 481.
linearis Berk. & Br., 481.
mucunae Rabh., 481.
sojae Syd., 481.
vignicola, 418.
wedeliae P. Henn., 481.
Ustilaginaceæ, 484.
Ustilaginales, 484.
Ustilaginoidea ochracea P. Henn., 494.
virens (Cke.) Takah., 494.
Ustilago andropogonis-aciculati Petch., 484.
flagellata Syd., 484.
isachnes Syd., 484.
manilensis Syd., 484.
sacchari Rabh., 484.
scitaminea (Rabh.) Syd., 484.
sorghi (Lk.) Pass., 484.
tonglinensis Tracy & Earle, 484.
Uvaria, 529.
rufa, 483.

V

Vaccination and vaccine therapy in treponematoses, 183.
Vallisneria, 71.
Valsaceæ, 510.
Valsaria citri Rehm, 511.
insitiva (de Not) Ces. & de Not, 511.
Vanilla sp., 503, 529.
VAZQUEZ-COLET, ANA, Rat-bite fever in the Philippines, 159.
Vermicularia breviseta Sacc., 526.
capsici Syd., 526.
fallax Sacc., 526.
horridula Sacc., 526.
merrilliana Sac., 526.
sesamina Sacc., 526.
xanthosomatis Sacc., 526.
Vernes, Wassermann, and Kahn reactions, comparative serologic study of, in experimental treponematoses, 241.
Vernonia vidali, 482.
Vigna sinensis, 518.
spp., 481, 484, 523.
Vladivostok Bay, plankton diatoms from, 77.

X

Xanthosoma sagittifolium, 526.
Xenopsylla cheopis, 556.
Xylaria allantoidea Berk., 513.
castorea Berk., 514.
corniformis Fr., 514.
euglossia Fr., 514.
grammica Mont., 514.
hypoxylon (L.) Grev. f. tropica Syd., 514.
luzonensis Henn., 514.
nigripes (Klot.) Sacc., 514.
obvata Berk., 514.
plebeja Ces., 514.
tabacina (Kickx.) Berk., 514.
tuberosa (Pers.) Cke., 514.
Xylariaceæ, 512, 513.

W

WEST, AUGUSTUS P., *see* CRUZ and WEST; *see also* SANTOS, WEST, and ESGUERRA.
Wood, decay of, in automobiles in the Tropics, 189.
Worm parasites of the brown rat (Mus norvegicus) in the Philippine Islands, 537.
Woroninella aecidioides (Peck.) Syd., 517.
dolichi (Cke.) Syd., 518.
psophocarpi Rac., 518.
puerariae (Henn.) Syd., 518.

Y

Yaws and syphilis, 177.
YEAGER, CLARK H., Bored-hole latrine equipment and construction, 681.
Ypselogonia Kln., 422, 435, 441.
peregrina Kln., 389, 422, 424, 441.
Ypsilonia cuspidata Lév., 526.
Yucca aloifolia, 521.

Z

Zea mays, 491, 501, 508, 519, 533, 534.
Zignoella (Trematostoma) nobilis Rehm, 503.
Zygomycetes, 520.
Zygosporium oscheoides Mont., 535.